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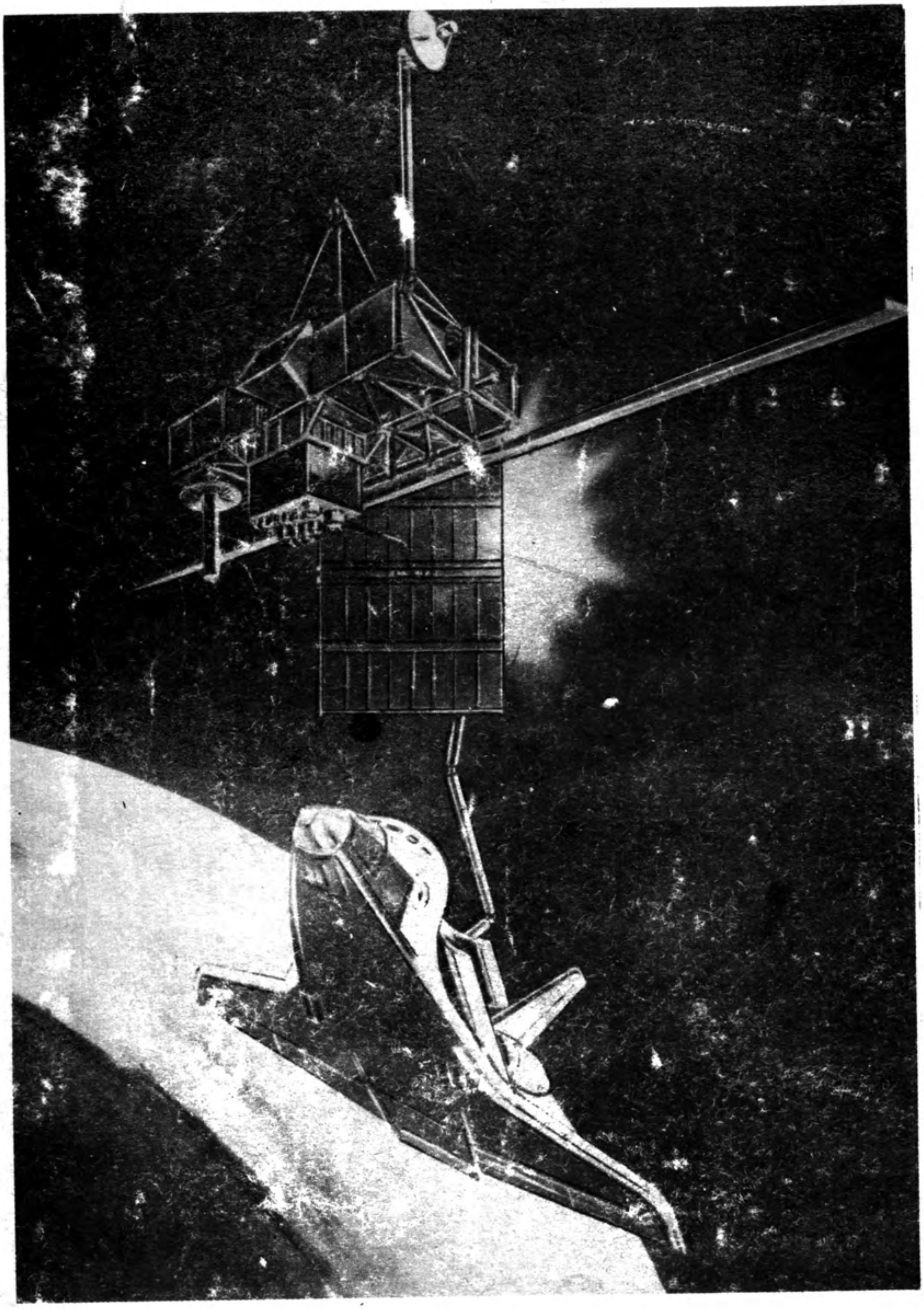

SPACEFLIGHT

A Publication of The British Interplanetary Society

Editor:
Kenneth W. Gatland, FRAS, FBIS

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CONTENTS

With this issue we return to our normal frequency of publication. We thank the many members who have written – some enclosing donations to our Development Appeal Fund – expressing appreciation of the Society's efforts to maintain our publishing programme despite the heavy burden of rising costs which forced us to reduce our output in the last quarter of 1980. Ed.

MILESTONES

September 1980

4 Orbit of Salyut 6 raised from 323 x 338 km, 91.08 minutes to 337 x 350 km, 91.34 minutes prior to the launch of Soyuz 38, using the Soyuz 37 engine.

8 Radio Moscow announces that Salyut 6 has been "elevated" to a higher orbit using the Progress 11 engine. Western observers actually detect an overall lowering of Salyut's orbit with perigee being reduced by 7 km. The change is more likely to have been due to a test of Soyuz 37's engine prior to its recovery with Popov and Ryumin aboard.

9 Cosmonauts Popov and Ryumin, having been in orbit over five months, begin a new series of experiments with the BST 1M submillimetre telescope which has a 4.9 ft (1.5 m) mirror, bigger than many ground-based telescopes. It is being used "to study the Earth's atmosphere, particularly the extent of pollution."

16 Minor orbital manoeuvre by Salyut from 333 x 345 km, 91.25 minutes to 335 x 352 km, 91.34 minutes to ensure ideal conditions for rendezvous with the upcoming Soyuz 38.

18 NASA announces that a Landsat ground station is to be established at Hartebeesthoek, near Johannesburg, South Africa "to receive, process, archive and disseminate Landsat data."

18 Soviets launch Soyuz 38 from Baikonur at 22 hr 11 min Moscow time with cosmonaut Lt-Col Yury Romanenko and Lt-Col Arnaldo Tamayo Mendez (Cuba). Married with two children, Mendez began training at the Gagarin Cosmonauts' Training Centre in March 1979. The Cuban reserve cosmonaut is José Armando.

19 Soyuz 38 docks with Salyut 6 space station to join resident crew of Lt-Col Leonid Popov and Valery Ryumin who have been aboard since 10 April

28 Soviets launch Progress 11 ferry with more oxygen, water, food and other supplies for Salyut 6.

29 Salyut 6 cosmonauts dock Progress 11 by remote control. Third anniversary of space station in Earth orbit.

31 NASA awards Boeing Aerospace $400,000 contract to study feasibility of building a space terminal 250 miles (400 km) above the Earth. The terminal, which could be used for refuelling space vehicles en route for geostationary orbit or deep space, would be assembled piece-by-piece from modules containing living quarters, service areas and warehouses. Study will last 12 months.

October 1980

1 Lt-Col Leonid Popov and Valery Ryumin exceed the previous space endurance record of 175 days 36 minutes.

5 Disclosed that the private company of Orbital Transport-und Raketen-Aktiengesellschaft (OTRAG), which set up a test site in Zaire in 1977, and was eventually forced out by Soviet and East German diplomatic pressure, is to re-start launch activity in Libya. A launch area is being prepared in the Libyan desert some 372 miles (600 km) south of Tripoli. A new series of rocket tests is scheduled to begin late this year, leading to the launch of a small satellite in 1983.

11 After spending 185 days in space, Lt-Col Leonid Popov and Valery Ryumin soft-land in Soyuz 37 some 111 miles (180 km) SE of Dzhezkazgan at 12 hr 50 min MT. In three space missions Ryumin has spent nearly a year in orbital flight.

17 Tass reveals that Popov and Ryumin both grew 1.18-in (3.0 cm) during their record-breaking space flight. Doctors found their muscles and spinal tissue had stretched but, exposed to normal Earth gravity, they were gradually returning to their normal height.

COVER

SHUTTLE PALLET SATELLITE. Great hopes for the future of space technology ride with the NASA Space Shuttle, leading to novel concepts for low-cost research. One is the SPAS (Shuttle Pallet Satellite) being developed by the Space Division of Messerschmitt-Bölkow-Blohm. The SPAS development is part of the trend toward modular multi-mission spacecraft. It takes the form of a pallet-type modular structure that bridges the cargo bay with modular sub-systems and experiments mounted on a standardised lattice-work platform. SPAS-O will remain inside the cargo bay. SPAS-1 (shown in this artist's impression) will be removed from the Shuttle cargo bay by means of the Remote Manipulator System in a 300 km, 23.5° orbit, on the seventh flight of the Space Transportation System. To be operated both by NASA and ESA, SPAS-1 will operate in a free-flying mode conducting "proximity experiments" and reberthing after periods of 10 to 30 hours.

Messerschmitt-Bölkow-Blohm

JBIS

The 12 monthly issues of *JBIS* for 1980 cover a wide range of technical space projects, with special sections on SPACE SCIENCE AND EDUCATION; SPACE TECHNOLOGY; ASTRONAUTICS HISTORY and INTERSTELLAR STUDIES.

The contents of the issues which have been published since the last list (*Spaceflight*, June 1980) are given below.

Members can obtain the 12 copies of *JBIS* for 1980 for £13.00 ($29.00), postage inclusive. The five INTERSTELLAR STUDIES issues include a completely revised and updated "Bibliography of Interstellar Travel and Communication" which can be purchased separately for £7.00 ($16.00). Single copies of any issue may be purchased at £1.50 each ($3.50) post free.

Orders can be included in the annual subscription renewal notice or sent separately to: The Executive Secretary, British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ.

January 1980 INTERSTELLAR STUDIES

L. D. Jaffe, *et al*	An Interstellar Precursor Mission.
G. Vulpetti	Noise-Effects in Relative Pure-Rocket Dynamics.

February 1980 SPACE TECHNOLOGY

I. V. Franklin	Solar Array Opportunities in the 1980's and Beyond.
M. B. Barnes, *et al*	The Miranda (X4) Infra-Red Experiment: Design, Performance and Earth Radiance Measurements.
D. M. Ashford	A Small European Shuttle.
R. M. Shelton	Solar Power Satellites – Challenge to European Industry.

March 1980 INTERSTELLAR STUDIES

G. L. Matloff and E. F. Mallove	The First Interstellar Colonisation Mission.
Monte Ross	Design of an Optical Receiver for Space Signals
R. A. Freitas, Jr.	Interstellar Probes: A New Approach to SETI
A. Bond and A. R. Martin	A Conservative Estimate on the Number of Habitable Planets in the Galaxy: Part 2.
C. E. Singer	Interstellar Propulsion using a Pellet Stream for Momentum Transfer.
A. A. Jackson	Some Considerations on the Anti-matter and Fusion Ram Augmented Interstellar Rocket.

April 1980 SPACE TECHNOLOGY

J. W. Heaton	Concepts for a European Multi-Role Spacecraft.
D. G. Fearn	The Use of Ion Thrusters for Orbit Raising.
E. Vallerani	The Potential Development of Spacelab Towards the Space Stations.

May 1980 SPACE AND EDUCATION

D. P. Thomas and C. R. Francis	Satellites We Have Known and Loved – A Synposis of the Scientific Results to date.
W. Wienss	Spacelab – Shelter and Habitat for Future Manned Missions.
P. A. Thyer	A Course in Astronomy and Space Science.
W. A. Kisko	Electric Propulsion Comes of Age.
G. K. C. Pardoe	The Industrialisation of Space.

June 1980 INTERSTELLAR STUDIES

E. F. Mallove, *et al*	Interstellar Travel and Communication: A Bibliography.

July 1980 INTERSTELLAR STUDIES

R. A. Freitas, Jr.	A Self-Reproaching Interstellar Probe.
M. D. Froning, Jr.	Propulsion Requirements for a Quantum Interstellar Ramjet.
E. J. Coffey	Computers and Intelligence.
P. M. Molton	Exobiology Notebook

August 1980 SPACE CHRONICLE

C. Peebles	A Traveller in the Night
W. I. McLaughlin	Prediscovery Evidence of Planetary Rings
N. L. Johnson	Trends of the Soviet Photographic Reconnaissance Programme
F. H. Winter	The American Rocket Society – 1930-1962

September 1980 IMAGE PROCESSING

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R. S. Stobie	Analysis of Astronomical Images Using Moments
E. Mattson	A Processor for Compression of Multi-Spectral Image Data On-Board Remote Sensing Satellites
A. Wood	The CLIP4 Array Processor
G. K. Skinner	Imaging of Cosmic X-ray Sources Using Coded Mask Telescopes

October 1980 IMAGE PROCESSING

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P. Norris	Image Processing for the ESA Faint Object Camera
E. Golton	Calibration and Image Processing for the Space Telescope Faint Object Camera
C. M. Gurney	The Detection of Linear Features Using Landsat Data
M. D. Lawden and D. Pearce	Making the Vicar Image Processing System Portable

November 1980 INTERSTELLAR STUDIES

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P. F. Clancy	Some Advantages of Wide Over Narrow Band Signals in the Search for Extraterrestrial Intelligence (SETI)
E. J. Coffey	The Nature of Living Organisms
F. Valdes and R. A. Freitas, Jr.	Comparison of Reproducing and Non-Reproducing Starprobe Strategies for Galactic Evolution

AMERICA'S FORGOTTEN ASTRONAUTS

By David J. Shayler and Philip W. Snowdon

Introduction

In addition to the 73 astronauts assigned to NASA in the 1959–1969 period[1] America had other groups of men engaged in astronaut training in the same period. Not all of these men are well known and it is the purpose of this article to reveal these groups and the men who formed them.

The astronaut-candidates were assigned to the USAF X-20 Dyna-Soar and Manned Orbiting Laboratory (MOL) programmes; several pilots of the X-15 research aircraft attained the astronaut rating when flying the plane, and USAF officers were assigned to a training programme for future USAF space programmes. It is on these areas that we shall mainly concentrate, but in addition America's involvement in the selection of Payload Specialists for the first few Spacelab missions will be covered.

The Programmes

The X-15 research aircraft was evolved from design studies back in 1952 and the first of three aircraft was rolled out in October 1958; for details of the X-15 programme see [2]. Pilots for the joint USAF/NACA/USN programme were selected in 1958. Four men were chosen, Captain Iven Kincheloe, USAF, who at the time was the world altitude record holder at 126,200 ft, and was a former X-2 pilot; from the Navy was Lt.Commander Forrest "Pete" Peterson; the NACA pilot was Joseph Walker; and contract pilot from North American Aviation was Scott Crossfield, who would be the first to pilot the aircraft.

In June 1958 Kincheloe was killed following a flame-out of his F-104 shortly after take-off; he attempted to eject but was too low to survive. His place in the X-15 programme was taken by his backup Major Robert M. White, USAF. In October 1958 the programme was taken over from NACA by the newly formed NASA and in the spring of 1959 four captive flights were made followed by the first of 199 free flights on 8 June 1959. The first flight under power was made on 17 September 1959. All these early flights were by Crossfield. A full flight log of all X-15 free flights can be found in ref [3].

Meanwhile, in April 1959, NASA had selected the first seven astronauts for the Mercury programme giving America her first astronauts. Throughout 1960–1968 the X-15 was stretched to the limits of its design and after further modifications, three aircraft gained invaluable experience in hypersonic flight and supplemented the manned space programmes of America in the same period. They were also to provide invaluable data for the evolution of the Space Shuttle.

In 1960 four other pilots were selected to fly the X-15 aircraft in a series of engineering missions: Lt.Commander Forrest S. Peterson, USN; John B. McKay, NASA; Neil A. Armstrong, NASA; and Robert A. Rushworth, USAF. Also in 1960 Crossfield left the X-15 programme and returned to North American Aviation[4].

Dyna-Soar

In 1961 the USAF initiated its man-in-space programme with the X-20 Dyna-Soar project designed to perform basically the mission outline of the launch and recovery of the present day Space Shuttle. The "space-glider" was to have been launched, atop of standard launch vehicle, into orbit and extend the research capabilities of the X-15 and provide first hand data and experience in controlling a winged spacecraft and its re-entry and conventional landing on a runway. The programme was not to develop experience in orbital flight but in the area of controlled precision re-entry and landing[5].

As part of the USAF preparation of its space programmes involving manned spacecraft the USAF organized three 8-month training courses between March and October 1962 at the Air Force Aerospace Pilots Training School, Edwards AFB, California; a total of 23 astronauts designees were chosen

SCOTT CROSSFIELD, test-pilot of North American Aviation, who flew the X-15 research aircraft in initial trials. Altogether he made 14 flights between 8 June 1959 and 12 June 1960.

North American Aviation

in three groups[6] as shown in Table 1. It will be noted that in Group 1, and listed as a Pilot Engineer Consultant, appears the name of Neil Armstrong; he was selected for this assignment whilst still assigned to the X-15 programme. Following the last flight in that plane he turned his attention full time to the X-20 programme whilst awaiting assignment to the NASA astronaut group.

In 1962 two pilots left the X-15 programme. Peterson returned to the Navy after making five flights in the aircraft; and White returned to the USAF. Meanwhile on 17 September 1962 NASA had selected its second Group of astronauts, which included Neil Armstrong. His place in the group assigned by the USAF to the Dyna-Soar programme was taken by Albert L. Crews from Group 2. It is possible that had Armstrong not been selected by NASA he would have been assigned to the Dyna-Soar project instead.

Three days after the NASA announcement of the "New Nine", which also included James A. McDivvitt who chose NASA instead of the X-15 programme[7] on 20 September the USAF announced the names of the six men who were to fly the Dyna-Soar. They were Crews; Gordon; Knight; Rogers; Thompson and Wood, the 1st Group of USAF astronaut designees.

Some 12 months later the USAF cancelled the Dyna-Soar programme in favour of developing a Manned Orbiting Laboratory and six Dyna-Soar pilots were re-assigned to other duties. Crews stayed with MOL; Gordon returned to active duty with the USAF; Knight became an experimental Test

TABLE 1 USAF ASTRONAUT DESIGNEE GROUPS

Group 1 Selected 15 March 1962. (Pilot Engineer-Consultants)

Neil A. Armstrong, NASA	Capt. H. C. Gordon, USAF
Capt. W. J. Knight, USAF	Capt. R. L. Rogers, USAF
M. L. Thompson, NASA	Maj. J. W. Wood, USAF

Group 2 Selected 20 April 1962. (Biog. Data from Assoc. Press Release 20 Apr 1962)

Capt. A. H. Crews, USAF	Capt. C. C. Bock, USAF
Capt. T. W. Twinting, USAF	Capt. R.W. Smith, USAF
Maj. D. L. Sorlie, USAF	Capt. R. H. McIntosh, USAF
Maj. B. F. Knolle, USAF	Lt.-Com. L. N. Hoover, USN

Group 3 Selected 22 October 1962. (Biog. Data from "Washington Post" 23 Oct 1962)

Capt. A. L. Atwell, USAF	Capt. C. A. Bassett, USAF
Major T. D. Benefield, USAF	Capt. M. Collins, USAF
Capt. N. R. Garland, USAF	Capt. J. M. Engle, USAF
Capt. E. G. Givens, USAF	Capt. F. G. Neubeck, USAF
Capt. J. A. Roman, USAF	Capt. A. H. Uhalt, USAF

Pilot at Edwards; Rogers also returned to active duty with the USAF; Thompson transferred to the X-15 programme, and Wood too returned to the USAF.

Other events in 1963 were the appointment of Captain Joseph H. Engle, USAF, to X-15 in June. In October NASA selected a further 14 astronauts, among them ex-USAF astronaut designees (Group 3) Bassett and Collins, and X-15 pilot Walker left the programme to become a test pilot at Edwards AFB. In 1964 a tenth pilot was assigned to the X-15 project, Captain William Knight, who was originally one of the Dyna-Soar pilots.

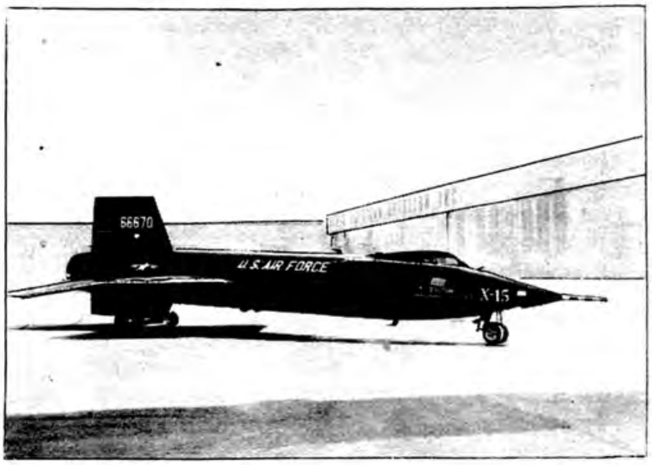
MOL Astronauts

Another pilot was chosen for the X-15 programme in 1965, civilian William Dana. The same year the USAF selected the first group of astronauts to be assigned to the MOL programme on 12 November 1965. Eight men were chosen: Michael J. Adams; Albert H. Crews, both USAF; John Lawrence Finley, USN; Richard E. Lawyer, USAF; Lachlan Macleay, USAF; Francis G. Neaubeck, USAF; James A. Taylor, USAF and Richard H. Truly, USN.

A second Group of pilots was assigned to the MOL programme on 17 June 1966: Karol J. Bobko, USAF; Robert Laurel Crippen, USN; Charles G. Fullerton, USAF; Henry W. Hartsfield, Jr., USAF and Robert F. Overmyer, USMC. In 1967 four more were selected: James A. Abrahamson, USAF; Robert T. Herres, USAF; Robert H. Lawrence, USAF and Donald H. Peterson, USAF; bringing the total to seventeen. The MOL programme was originally conceived to determine the usefulness of man in space in a military role and was to rely on the experience gained in the Gemini programme using that spacecraft as a ferry and the Titan III launch vehicle which was to have boosted the MOL into orbit with the Gemini on top; the spacecraft was then to return to Earth after a mission lasting about 30 days.

X-15 continues

While the USAF continued with MOL several events in the years 1966–67 were marked in the X-15 programme. In March 1966 Neil Armstrong, an ex-X-15 pilot, flew into orbit aboard Gemini 8. Another pilot, Joseph Engle, was selected for NASA's fifth group of astronauts (also selected with Engle was Charles M. Duke, USAF)[8], Robert A. Rushworth left the X-15 programme in 1966 to return to the USAF after making 34



First of three X-15 research aircraft which blazed the trail into space. Note that the lower vertical stabiliser was removed while on the ground. Speed brakes were located on both vertical stabilisers.

North American Aviation

flights in that aircraft, the greatest number of any pilot. McKay also left the X-15 programme in 1966 from injuries sustained in the 1962 X-15 crash.

Also in 1966 a MOL astronaut transferred to the X-15 programme, Adams became the 12th pilot to fly the aircraft and on 15 November 1967, on his seventh flight, was the first and only one of the twelve X-15 pilots to lose his life. He had succeeded in reaching an altitude of 266,000 ft (thereby attaining the Astronaut designation) but became disorientated and the plane went out of control and crashed near Johannesburg, California[9].

Another former X-15 pilot died on 8 June 1966, Joseph Walker, the second X-15 pilot flew too close to an XB-70 aircraft in his F-104, and ripped into the larger craft's wing; both crashed killing the co-pilot of the XB-70 and Walker in the F-104; the pilot of the XB-70 successfully ejected but his co-pilot did not[10].

Two other forgotten astronauts died in 1967. On 13 September 1967 former X-20 Dyna-Soar pilot Russell L. Rogers

TABLE 2 X-20 DYNA-SOAR AND MANNED ORBITING LABORATORY (MOL) ASTRONAUTS BY GROUP

X-20 Dyna-Soar Astronauts – selected 20 September 1962

Capt. A. H. Crews, USAF	Capt. H. C. Gordon, USAF
Capt. W. J. Kight, USAF	Capt. R. L. Rogers, USAF
M. L. Thompson, NASA	Maj. J. W. Wood, USAF

Manned Orbiting Laboratory Astronauts:
Group 1, selected 12 November 1965

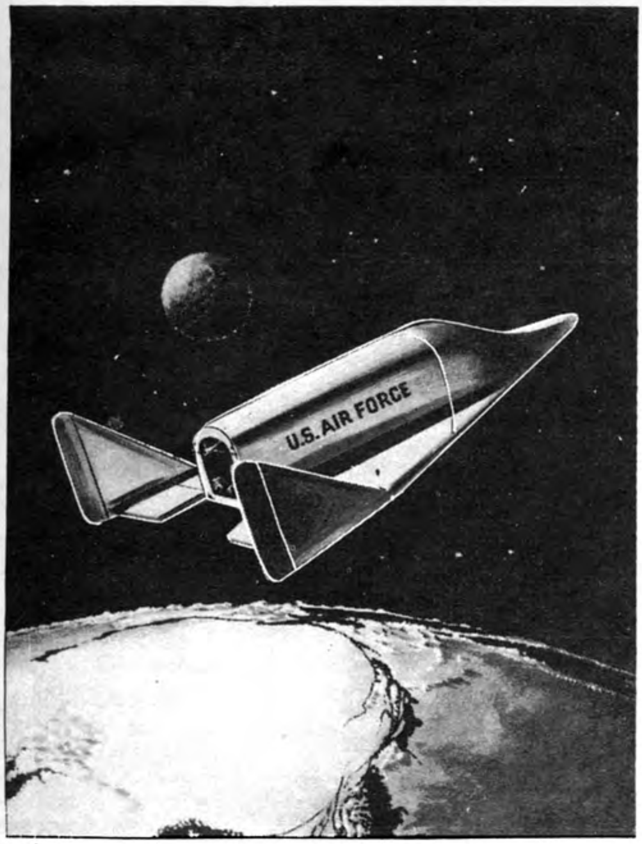
Maj. M. J. Adams, USAF	Maj. A. H. Crews, USAF
Lt.-Comdr. J. L. Finley, USN	Capt. R. E. Lawyer, USAF
Maj. L. Macleay, USAF	Capt. F. G. Neubeck, USAF
Maj. J. A. Taylor, USAF	Lt. R. H. Truly, USN

Group 2, selected 17 June 1966

Capt. K. J. Bobko, USAF	Lt. R. L. Crippen, USN
Capt. C. G. Fullerton, USAF	Capt. H. W. Hartsfield, USAF
Capt. R. F. Overmyer, USMC	

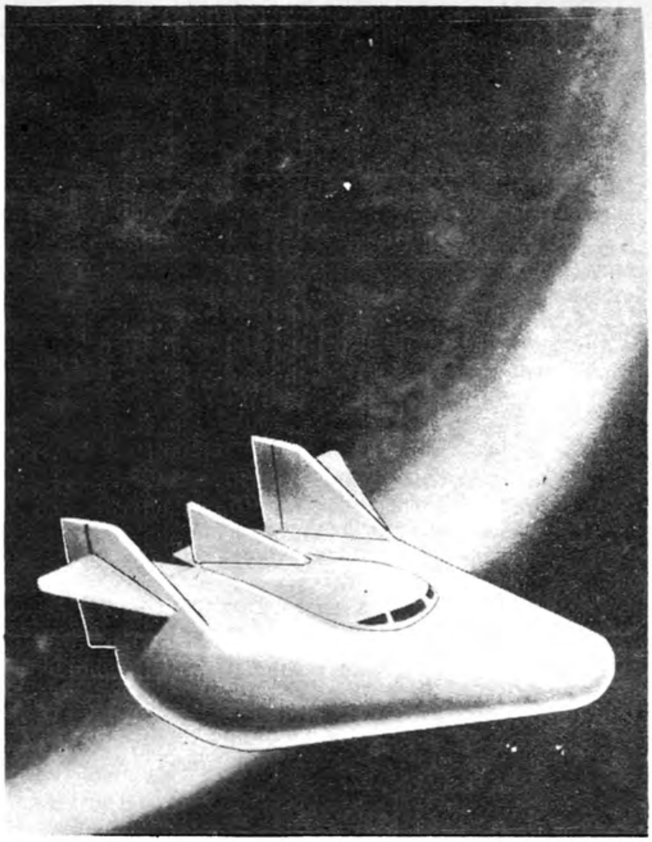
Group 3, selected 30 June 1967

Maj. J. A. Abrahamson, USAF	Lt.-Col. R. T. Herres, USAF
Maj. R. A. Lawrence, USAF	Maj. D. H. Peterson, USAF



X-20 Dyna-Soar, the spaceplane intended to take over from the X-15 at the frontiers of space but which never flew.

Boeing Aerospace



Another abandoned project – an orbital version of the M-2 lifting body proposed by NASA's Ames Research Center in the early 'Sixies. It was meant to ferry astronauts to an orbiting space station.

NASA

lost his life in an explosion of his F-105 aircraft near Kandena Air Force Base, Okinawa; and on 8 December 1967 America's first negro astronaut, Robert H. Lawrence, Jr. of the MOL programme, died in the crash of an F-104 at Edwards Air Force Base, California.

On 21 January 1968, reductions in the NASA budget saw the end of the X-15 programme in sight, with the termination of the programme coming not later than 31 December 1968. In the final year of flight operations only the 1st aircraft was flown eight more times; the two pilots Dana and Knight flew the X-15 towards space, each one gaining experience for the Shuttle on which in 1968 NASA was beginning definitive studies. Although the 200th flight of the aircraft could not take place, the X-15 aircraft fully justified its design objectives in the 10 years of use, spanning the gap between conventional aircraft to spacecraft.

The two pilots who remained in the X-15 programme were reassigned following the end of the flight programme. Knight returned to active duty in the Air Force, while Dana became a research pilot at the Dryden Flight Research Center at Edwards, and was assigned to the lifting body programme there[11].

TABLE 3 X-15Pilots Summary (in order of first flight

Pos.	Name	Service	Selected	First Flight	Last Flight	Total	Greatest Height Attained (ft)
0.	Kincheloe, I. C.	USAF	1958	Killed before first X-15 flight			
1.	Crossfield, A. S.	NAA	1958	06/08/59	06/12/60	14	88,116
2.	*Walker, J. A.(2)	NACA(NASA)	1958	03/25/60	08/22/63	25	354,200
3.	*White, R. M. (1)	USAF	1958	04/13/60	12/14/62	16	314,750
4.	Petersen, F. S.	USN	1958	09/23/60	01/10/62	5	101,800
5.	*McKay, J. B. (5)	NASA	1960	10/28/60	09/08/66	29	295,600
6.	*Rushworth, R. A. (3)	USAF	1958	11/04/60	07/01/66	34	285,000
7.	Armstrong, N. A.	NASA	1960	11/30/60	07/26/62	7	207,550
8.	*Engle, J. H. (4)	USAF	1963	07/10/63	10/14/65	16	280,600
9.	Thompson, M.O.	NASA	1963	10/29/63	08/25/65	14	214,100
10.	*Knight, W. J. (7)	USAF	1964	09/30/65	09/13/68	16	280,500
11.	*Dana, W. H. (6)	NASA	1965	11/04/65	10/24/68	16	306,900
12.	*Adams, M. J. (8)	USAF	1966	11/29/66	11/15/67	7	266,000

*Attained Astronaut rating by flying X-15 aircraft above 264,000 feet (50 miles or 80 km), in order of attainment.

Cancellation of MOL

Meanwhile the MOL programme continued although no flights were made in 1968 as planned. But as the programme progressed into 1969 and with still no manned flight planned, the USAF began looking at a replacement project, unmanned this time, which would fulfill the MOL objectives on a much reduced budget. As this research increased, backing for the manned programme decreased until finally on 10 June 1969 it was officially announced that the MOL programme had been terminated due to lack of funds and increase in the unmanned programme which became the Big Bird project[12].

Following the cancellation of the MOL programme the pilots assigned to the project were reassigned (Abrahamson; Finley; Herres; Lawyer; Macleay; Neubeck and Taylor) returned to their parent services on active duty, while Crews joined NASA as a member of the Flight Crew Directorate at Johnson Space Center, Houston. The remaining seven MOL astronauts were selected, on 14 August 1969, to become the seventh group of NASA astronauts. They were Bobko, Crippen, Fullerton, Hartsfield, Overmyer, Peterson and Truly, who were subsequently assigned to support duties in the Apollo programme between 1971–1975.

In July 1969 a former X-15 pilot became the first man on the Moon. Neil A. Armstrong became the first moon walker on 20 July 1969; with him on the historic Apollo 11 was former group 3 astronaut designee Michael Collins.

In 1971 Armstrong left NASA to persue a civilian career as a college professor (Collins had left in December 1969 and by 1971 became Director of the Smithsonian Museum which houses the 1st X-15 in its galleries).

The Shuttlenauts

In 1970 the results obtained in the USAF programmes, the X-15 project and those still being obtained in the lifting body programme, were beginning to reach fruition in the beginnings of the American Space Shuttle programme. It is interesting to note what role in this programme former X-15 and MOL astronauts played.

Two more astronauts had lost their lives after leaving their respective programmes. In September 1970 former MOL pilot James. M. Taylor was killed in the crash of his T-38 jet near Palmdale, California; then on 27 April 1975, John B. McKay died as a result of injuries sustained in the crash of his X-15 on 9 November 1962[13].

The following year three men were assigned to the ALT series of flights in the Space Shuttle programme. Former X-15 pilot Joe Engle (who had lost his place as LMP Apollo 17 due to crew reassignments) and former MOL astronauts Fullerton and Truly joined Fred Haise in qualifying the Shuttle Orbiter for landings on a conventional runway.

In April 1978 it was announced that Robert Crippen would be Pilot for the first manned Shuttle flight in 1980 to be followed by Engle, Truly and Fullerton on later OFT's. Undoubtably the remaining Group 7 astronauts will be assigned to early Shuttle missions.

DoD astronauts in space

So far the American armed forces have no plans to recruit astronauts for their own missions within the Shuttle programme. Originally the USAF was planning to foot the bill for the fifth orbiter but this was prevented by budget cuts in

The men who made it to the Moon. Neil Armstrong, Michael Collins and "Buzz" Aldrin stand before the Command Module "Columbia" on the Tenth Anniversary of Apollo 11, the first Moon landing. Picture was taken on 20 July 1979 at the National Air and Space Museum, Washington, D.C.

Pioneers of a new breed of astronauts typified by Bob Crippen and John Young who will ride the Space Shuttle "Columbia" into orbit.

Photos: Stephen Smyth

recent years. However, DoD service men and women will no doubt attend DoD experiments on Shuttle flights as Payload Specialists and will receive training at JSC. Further to DoD payloads it has been stated that: "the orbits of DoD satellites, physical characteristics and launch dates may be classified", according to testimony before the House on 29 March 1979. Security for DoD Shuttle missions will be achieved by converting NASA facilities at JSC to a "controlled mode" of operations by which the Pentagon will protect its flight preparations, training and control operations with minimum impact on civil space operations. The Air Force intends to modify JSC Mission Control Center, Shuttle mission simulator and crew activity/planning and computer facilities there"[14].

Eventually the American DoD will operate a semi-permanent manned space station in orbit similar to the current military Salyut programme operated by the Soviet Union and incorporating experience gained from Dyna-Soar, MOL and the Big Bird programmes. Until these stations are available the DoD will have to be content with "passenger" flights aboard NASA space shuttles of short duration. Whatever the outcome of man's military usefulness in space the experience and data gained from the X-15, X-20 and MOL programmes as well as the lifting-body series to the problems of reuseable supply spacecraft and the creation of permanent orbital space bases, will not be forgotten even though some of the astronauts assigned to those programmes have been.

The Astronauts

ABRAHAMSON, James A. (MOL)
Major General James A. Abrahamson, USAF, was born on 19 May 1933 in Inglewood, California. He is married with two children. He received a bachelor of science degree in aeronautical engineering from the Massachusetts Institute of Technology and a master of science in aerospace engineering from the University of Oklahoma. He was selected for the USAF MOL programme on 30 June 1967 (Group 3) and following the programme's cancellation in June 1969 he became a member of the National Aeronautics and Space Council serving on that committee until it was dissolved in 1973. He subsequently returned to active duty in the USAF. He became Inspector General, Air Force Systems Command, Andrews AFB, Maryland and is currently assigned as USAF F-16 Program Director, Air Force Systems Command, Wright Patterson Air Force Base, Ohio (following a term as Deputy Director of that programme). He has also recently been assigned as one of the Special Senior Staff Support to Management of the Space Shuttle Transportation System, at the Johnson Space Center[15].

ADAMS, Michael James (MOL, X-15)
Major Michael J. Adams, USAF was born on 5 May 1930 in Sacramento, California. He was married with three children. Adams received a bachelor of science degree in aeronautical engineering from Oklahoma University (1958) and was chosen for the MOL programme on 12 November 1965 (Group 1); the next year he transferred to the X-15 programme and made seven flights between 29 November 1966 and 15 November 1967. He was the 12th and last man to fly the X-15 and attained the astronaut rating on his last flight, which also resulted in his death on 15 November 1967, following disorientation during re-entry causing the craft to spin out of control and crash near the Edwards AFB. He was the only pilot to lose his life whilst flying the X-15.

ARMSTRONG, Neil Alden (X-15, USAF Astro Designee, NASA)
Mr. Neil A. Armstrong, a civilian test pilot, was born on 5 August 1930 in Wapakoneta, Ohio. He is married with two children. After receiving a bachelor of science degree in aeronautical engineering from Purdue University in 1955, he became an Aviator in the US Navy and subsequently received a master of science in aerospace engineering from the University of Southern California (1970). After his attendance at Purdue University he joined NACA Lewis Research Center, then NASA High Speed Flight Station at Edwards AFB, on assignment to the Manned Spacecraft Division of the AFFTC, Edwards. Selected for the X-15 programme in 1960 and flew that craft seven times between 30 November 1960 and 26 July 1962 attaining his highest altitude of 207,550 ft on his 6th flight on 20 April 1962. Selected as a Pilot Engineer Consultant for the USAF manned space programmes on 15 March 1962, he completed an eight month course of training at the AF Aerospace Pilots Training School, Edwards AFB, California; before completion, however, on 17 September 1962 he was selected to join the NASA Astronaut group (Group 2) (see [16] for NASA service and current status).

ATWELL, Alfred L. (USAF Astronaut Designee)
Alfred L. Atwell was born in North Garden, Virginia; was a graduate of the University of Virginia and had been an AF officer since 1952. At the time of his appointment as an Astronaut designee on 22 October 1962 he was a 33-year old Captain in the USAF.

BASSETT, Charles A. (Astronaut Designee, NASA)
Major Charles A. Bassett, II, USAF, was born on 30 December 1931 in Dayton, Ohio; he is married and has two children. He had received a bachelor of science in electrical engineering from Texas Technological College, before being assigned as an USAF Astronaut Designee on 22 October 1962 (Group 3). On 18 October 1963 he was selected for the third Group of NASA astronauts[17].

BENEFIELD, Tommie D. (Astronaut Designee)
Selected as a Group 3 Astronaut designee on 22 October 1962, and at that time a 33-year old Major in the USAF, Tommie D. Benefield was born in Jefferson, Texas and was a former troop carrier pilot stationed at Sewart AFB, Tenn.

BOBKO, Karol Joseph (MOL, NASA)
Lieutenant Colonel Karol J. Bobko, USAF, was born on 23 December 1937 in New York City, New York state, and is married with two children. He received a bachelor of science degree from the USAF Academy in 1959 and a master of science in aerospace engineering from the University of Southern California in 1970. He was selected for the MOL programme on 17 June 1966 (Group 2) and then as a Group 7 NASA astronaut on 14 August 1969[18].

BOCK, Jr., Charles C. (Astronaut Designee)
Selected on 20 April 1962 as a USAF Group 2 astronaut designee, Charles Bock was born in Council Bluffs, Iowa. At the time of selection he was a 36-year old Captain, married with 2 children, and was assigned to Andrews AFB, Maryland, HQ, AFSC.

COLLINS, Michael (Astronaut Designee, NASA)
Major General Michael Collins, USAFR, was born on 31 October 1930 in Rome, Italy. He is married and has three children. He received a bachelor of science degree from the US Military Academy in 1952 and was a Group 3 USAF astronaut designee selected 22 October 1962 before transferring to NASA as one of 14 Group 3 astronauts on 18 October 1963[17].

CREWS, Jr., Albert H. (X-20 Dyna-Soar, MOL)
Colonel Albert H. Crews, Jr, USAF, was born on 23 March 1929 in El Dorado, Arkansas, and is married with three children. He received a bachelor of science degree in chemical engineering from the University of Southern Louisiana (1950) and a master of science in aeronautical engineering from the

Air Force Institute of Technology. When selected as Group 2 USAF Astronaut designee on 20 April 1962 he was stationed at Edwards AFB and underwent an eight month astronaut training course. He replaced Armstrong as a Group 1 astronaut designee when Armstrong was selected by NASA in September 1962. Selected to fly the X-20 Dyna-Soar on 20 September 1962, and following that programme's cancellation in 1963, he went to work on the USAF MOL programme. On 12 November 1965 he was to become one of the first group of astronauts assigned to the MOL programme, and after the termination of that programme in June 1969 he transferred to the NASA Flight Crew Operations directorate at Johnson Space Center, Houston, Texas. He is currently still employed at JSC.

CRIPPEN, Robert Laurel (MOL, NASA)
Commander Robert L. Crippen, USN, was born on 11 September 1937 in Beaumont, Texas. He is married and has three children. He received a bachelor of science degree in aerospace engineering from the University of Texas in 1960 and was selected for the MOL programme on 17 June 1966 (Group 2). Upon cancellation of the MOL programme he transferred to the NASA astronaut corps as one of 7 Group 7 Ex MOL astronauts on 14 August 1969 (for NASA assignments see [18]).

CROSSFIELD, Albert Scott (X-15)
Scott Crossfield, a civilian, was born on 2 October 1921 in Berkeley, California, and is married with six children. He received a bachelor of science degree from the University of Washington in 1949 and a master of science degree in aeronautical engineering from the University of Washington in 1950. As a test pilot for the prime contractor of the X-15 aircraft, North American Aviation, he was selected for the X-15 programme in 1958 and made 14 flights between 8 June 1959 – 12 June 1960, as well as the initial series of four captive flights, in the spring of 1959. He flew the first glide and the first powered flights in the programme and attained a maximum altitude of 88,116 ft on his sixth flight on 11 February 1960. When in 1960 the programme was turned over to NASA Crossfield left the flight programme but continued at North American Aviation as Director of Test and Quality Assurance. He has also directed research and development programmes for Eastern Airlines, and is currently a consultant in Washington, D.C.

DANA, William Harvey (X-15)
Civilian test pilot William H. Dana was born on 3 November 1930 in Pasadena, California, and is married with four children. He received a bachelor of science degree from the US Military Academy in 1952 and a master of science degree in aeronautical engineering from the University of Southern California in 1958. A former Air Force pilot he joined the X-15 programme in 1965 and made a total of 16 flights in the aircraft between 4 November 1965 and 24 October 1968. He made the last X-15 flight and attained his greatest altitude on his sixth flight on 1 November 1966, when he reached 306,900 ft and attained the astronaut title. Following the completion of the programme in 1968 Dana became a research pilot at NASA's Dryden Flight Research Center, Edwards, California. He became assigned to the lifting body programme and made his first flight on 25 April 1969 in the unpowered HL-10 lifting body. He continued in the lifting body programme as a research pilot until 1975 when X-24B project was completed. He is currently still assigned to the Flight Research Center as a research pilot.

ENGLE, Joseph Henry (USAF Astro Designee; X-15 NASA)
Colonel Joe H. Engle, USAF was born on 26 August 1932 in Abelene, Kansas, and is married with two children. He received a bachelor of science degree in aeronautical engineering from the University of Kansas in 1955. He was selected as Group 3 astronaut designee for the USAF programme on 22 October 1962. Chosen for the X-15 programme in June 1963 he made 16 flights between 10 July 1963 and 14 October 1965, attaining his greatest altitude of 280,600 ft on his 13th flight on 29 June 1965 attaining astronaut rating. He was selected for the NASA astronaut programme on 4 April 1966, as one of 19 pilot astronauts[19].

FINLEY, John Lawrence (MOL)
Captain John L. Finley USN was born on 22 December 1935 in Winchester, Massachusetts and is married with two children. He received a bachelor of science degree from the US Naval Academy in 1957 and was selected for the MOL programme on 12 November 1965 (Group 1). When the programme was terminated in June 1969 Finley returned to operational flying duty with the Navy. Some of his recent assignments have been with the Navy Department's Bureau of Personnel, Washington, DC (1975); Commander of an attack carrier Air Wing 5, FPO San Francisco (1976); Commanding Officer, Naval Schools Command, San Francisco, California (1977), and with the *USS Kawishiwi*, FPO San Francisco (1978).

FULLERTON, Charles Gordon (MOL, NASA)
Lieutenant Colonel Charles G. Fullerton, USAF was born on 11 October 1936 in Rochester, New York, and is married with two children. He received a bachelor of science degree in mechanical engineering from the California Institute of Technology in 1957 and a master of science degree in mechanical engineering from CalTec in 1958. On 17 June 1966 he was selected for the MOL programme (Group 2). He transferred to NASA on 14 August 1969 when the MOL programme was cancelled[18].

GARLAND, Neil R. (USAF Astro Designee)
Born in Hicksville, New York and selected for the USAF Astronaut Training programme on 22 October 1962 at the age of 34. He was at the time Chief of the Experimental Test Pilot Branch, Edwards AFB.

GIVENS, Jr., Edward Galen (USAF Astro Designee, NASA)
Born on 5 January 1930 in Quanah, Texas, Major Edward G. Givens, Jr., USAF, married with two children, received a bachelor of science degree from the US Naval Academy in 1952 and was selected for the USAF astronaut training course on 22 October 1962 (Group 3). In 1966 on 4 April, he was appointed to the NASA astronaut corps[19].

GORDON, Henry C. (USAF Astro Designee, X-20 Dyna-Soar)
Colonel Henry C. Gordon, USAF (Retd), was born on 23 December 1925 in Valparaiso, Indiana and is married with four children. He received a bachelor of science degree in aeronautical engineering from Purdue University in 1950 and was one of six Pilot Engineering Consultants assigned to the USAF astronaut training programme on 15 March 1962. He was selected for the Dyna-Soar programme on 20 September 1962 and following the cancellation of the programme in 1963 remained on active duty with the Air Force until his retirement in 1975. His last assignment was at Hill Air Force Base, Utah.

HARTSFIELD, Jr., Henry Warren (MOL; NASA)
Colonel Henry W. Hartsfield, Jr., USAF (Retd) was born on 21 November 1933 in Birmingham, Alabama and is married with two children. He received a bachelor of science degree in physics from Auburn University in 1954 and in 1971 a master of science degree in engineering science from the University of Tennessee. He was selected for the MOL programme on 17 June 1966 and following cancellation of that programme transferred to the NASA astronaut group on 14 August 1969 (Group 7)[18].

HERRES, Robert Tralles (MOL)
Brigadier General Robert Tralles Herres, USAF was born in

Denver, Colorado on 1 December 1932 and is married with three children. He received a bachelor of science degree from the US Naval Academy in 1953, a master of science degree in electrical engineering from the Air Force Institute of Technology, and a master of science degree in public administration from George Washington University. He was selected for the MOL programme as one of the last group of pilots so assigned on 30 June 1967 (Group 3) and when the programme was terminated two years later he remained on active duty with the Air Force, serving on various assignments and becoming Assistant Chief of Staff, Communications and Computer Resources, Air Force Headquarters, Washington, DC[20]. He is currently Director of C3 in the office of the AF deputy chief of staff for operations, plans and readiness.

HOOVER, Lloyd N. (USAF Astro Designee)
Named on 20 April 1962 as one of the second group of pilots assigned to the USAF astronaut training course at Edwards AFB, he was at the time of his selection a 37 year old Major in the USAF and married with two children. Born in Springfield, Mass., he had attended the Empire Test Pilot School, Farnborough, England in 1960, and at the time of his selection to the training course at Edwards, Hoover was stationed at HQ Weapons System Test Division, Naval Air Training Center, Patuxent River, MD.

KINCHELOE, Iven C. (X-15)
Captain Iven C. Kincheloe, USAF, one of America's greatest test pilots was a former Bell X-2 pilot before being assigned to the X-15 programme as an Air Force experimental test pilot in 1957. A married man, Kincheloe had attained the World altitude height record of 126,200 ft in the X-2 aircraft. Unhappily, in June 1958 he was killed when the F-104 he was flying suffered a flame-out shortly after take off; he ejected but was too low. In memory of this fine pilot a Society of Experimental Test Pilot's (STEP) Award was established.

KNIGHT, William J. (USAF Astro Designee; X-20 Dyna Soar; X-15)
Colonel William "Pete" J. Knight, USAF, was born on 18 November 1929 in Noblesville, Indiana, and is married with two children. He received a bachelor of science degree in aeronautical engineering from the Air Force Institute of Technology in 1958, and was selected for the USAF astronaut training programme on 15 March 1962 (Group 1). On 20 September 1962 he was named as one of six pilots assigned to the X-20 programme. Following the cancellation of the programme in 1963 he continued his studies at the Aerospace Research Pilots School and following graduation in 1964 was assigned to the X-15 programme making a total of 16 flights between 30 September 1965 and 13 September 1968, attaining his greatest altitude during his 13th flight on 17 October 1967; he reached a height of 280,500 ft and thus gained the Astronaut title. He was also able to record the fastest speed during the X-15 programme on 3 October 1967 when in the second aircraft he reached Mach 6.70 (4520 mph or 7,270 km/h). He returned to active flight duty with the Air Force when the programme terminated in December 1968. His current assignment is as System Program Director, Fighter Attack Systems Program Office, Air Force Systems Command, Wright Patterson Air Force Base, Ohio.

KNOLLE, Byron F. (USAF Astronaut Designee)
Named as Astronaut Designee on 20 April 1962 (Group 2), Byron F. Knolle at that time was a 38 year old Major in the USAF, married with two children. Born in Houston, Texas, he was assigned to the USAF HQ Space Systems Division in Los Angeles, California.

LAWRENCE, Jr., Robert Henry (MOL)
Major Robert H. Lawrence, Jr., USAF, was born on 2 October 1935 in Chicago, Illinois, and was married with one child. He received a bachelor of science degree in chemistry from Bradley University in 1956 and a doctorate in nuclear chemistry from Ohio State University in 1965. He was selected for the MOL programme on 30 June 1967 (Group 3). He was the first Black astronaut selected for training but tragically, on 8 December 1967, lost his life in the crash of an F-104 at Edwards AF Base, California. Had he lived he would have probably been transferred from the MOL programme to a NASA assignment in August 1969 when the former was cancelled. He would today have been preparing for his first spaceflight aboard the Space Shuttle.

LAWYER, Richard E. (MOL)
Colonel Richard E. Lawyer, USAF, was born on 8 November 1932 in Los Angeles, California; he is married with three children. He received a bachelor of science degree in aeronautical engineering from the University of California in 1955 and was chosen for the MOL programme on 12 November 1965 (Group 1). Following the cancellation of the MOL programme he remained with the Air Force and returned to active flight duty. He is currently Deputy Commander, Test Evaluation Directorate, Air Weapons Center, Tyndall AF Base, Florida.

MACLEAY, Lachlan (MOL)
Colonel Lachlan Macleay, USAF (Retd), was born on 13 June 1931 in St Louis, Missouri, and is married with three children. He received a bachelor of science degree from the US Naval Academy in 1954. He was selected for the MOL programme on 12 November 1965 (Group 1) and following the cancellation of the programme in June 1969, he returned to flight duty with the Air Force. He has held varous posts since 1969 and some of his most recent assignments in the Air Force have been at the War College, Maxwell Air Force Base, Alabama (1975); Aerospace Systems Division, Wright-Patterson AFB, Ohio (1976); Assistant Deputy Chief of Staff/Requirements, Headquarters TAC, Langley Air Force Base, Virginia (1977). He retired from the Air Force on 1 May 1978.

McINTOSH, Robert H. (USAF Astro Designee)
Named an Astronaut Designee on 20 April 1962 (Group 2) Robert H. McIntosh at that time was a 35 year old Captain in the Air Force, married with three children. He was stationed at Edwards AFB, California, and had just completed the experimental flight test course, a prerequisite for the astronautics course.

McKAY, John B. (X-15)
Civilian Test Pilot John B. McKay was born on 8 December 1922 in Portsmouth, Virginia. He was married and had eight children. He flew as a Navy pilot in the Pacific theater in World War 2 and received a bachelor of science degree from Virginia Polytechnic Institute in 1950. In February 1951 he joined NACA as an aeronautical research engineer and pilot, and in 1960 joined the X-15 programme under NASA auspices at the Flight Research Center Edwards AFB. He made a total of 29 flights in the X-15 between 28 October 1960 and 8 September 1966, achieving his greatest altitude on 28 September 1965 during his 23rd flight at 295,600 ft (90.1 km), thus attaining the Astronaut title. On 9 November 1962, during an emergency landing of the second X-15 craft, McKay sustained serious injury to his back. Although he recovered sufficiently to continue flying, his injuries forced him to retire from the programme in 1966. These injuries were to continue to trouble him until his death on 27 April 1975, as a result of complications stemming from the X-15 crash.

NEUBECK, Francis Gregory (Astro Designee, MOL)
Colonel Francis G. Neubeck, USAF was born on 11 April 1932 in Washington, DC, and is married with one child. He

received a bachelor of science degree from the US Naval Academy in 1955, and was selected for the USAF astronautics course on 22 October 1962 (Group 3). He was selected for the MOL programme on 12 November 1965 (Group 1), and following its cancellation in June 1969 he returned to active flight duty in the AF. He is currently Assistant Deputy Chief of Staff/Requirements, Headquarters TAC, Langley AFB, Virginia.

OVERMYER, Robert Franklyn (MOL, NASA)
Lieutenant Colonel Robert F. Overmyer, USMC was born on 14 July 1936 in Lorain, Ohio, and is married with three children. He received a bachelor of science degree in Physics from Baldwin-Wallace College in 1958 and a master of science degree in aeronautics at the US Naval Postgraduate Graduate School in 1964. He was selected for the MOL programme on 17 June 1966 (Group 2) before transferring to NASA on 14 August 1969 (Group 7). For subsequent NASA service see [18].

PETERSEN, Forrest Silas (X-15)
Vice-Admiral Forrest S. Petersen, USN, was born on 16 May 1922 in Holdrige, Nebraska and is married with three children. He joined the US Navy as an ensign on 7 June 1944 following a shortened course of instruction due to World War 2 at the US Naval Academy in Annapolis, Maryland. He completed destroyer duty in the Pacific theatre of WW2 in the last year of the war. He was assigned to the Naval Air Station, Pensacola, Florida in January 1946 and received his wings on 14 June 1947. During his various assignments in the Navy in the years up to 1958 he furthered his educational attainments. He received a bachelor of science degree from the US Naval Academy in 1944, a bachelor of science degree in aerospace engineering from the US Naval Postgraduate School in 1952, and a master of science degree in engineering from Princeton University in 1953. In August 1958 he was assigned to the X-15 programme and between 23 September 1960 and 10 January 1962 he made five flights in that programme attaining his greatest altitude of 101,800 ft (31 km) during his fourth flight on 28 September 1961. Following his last flight in January 1962 he was detached from the programme to return to duties in the Navy. He has held numerous positions since leaving the X-15 programme in 1962 and is currently Commander, Naval Air Systems Command, Department of the Navy, Washington, DC.

PETERSON, Donald Herod (MOL, NASA)
Colonel Donald H. Peterson, USAF was born on 22 October 1933 in Winona, Mississippi and is married with three children. He received a bachelor of science degree from the US Military Academy in 1955 and a master of science degree in nuclear engineering from the Air Force Institute of Technology in 1962. He was selected for the MOL programme on 17 June 1967 (Group 3) and transferred to the NASA Astronaut office, JSC, Houston, Texas on 14 August 1969 (Group 7)[18].

ROGERS, Russell L. (USAF Astro Designee, X-20 Dyna-Soar)
Major Russell L. Rogers, USAF was born on 12 April 1926 in Lawrence, Kansas; he was married with four children. After gaining a bachelor of science degree in aeronautical engineering from the University of Colorado in 1958 he was selected for the USAF astronautics course on 15 March 1962 while assigned to the Air Force Test Center as an experimental flight test pilot. He was designated as a Pilot Engineer Consultant. He was assigned to the Dyna-Soar programme on 20 September 1962 and following the cancellation of that programme in 1963 he returned to active flight duty in the Air Force. He died in an F-105 explosion near Kadena Air Force Base, Okinawa.

ROMAN, James A. (Astro Designee)
Named as a Group 3 USAF Astronaut Designee on 22 October 1962 James A. Roman was a Captain in the USAF, 35 years old at the time of selection. He was born in Paris, France and lived in Europe for the first 18 years of his life. He joined the USAF in 1956 and was a Medical Doctor.

RUSHWORTH, Robert A. (X-15)
Major General Robert A. Rushworth, USAF was born on 9 October 1924 in Madison, Maine, and is married with one child. He received a mechanical engineering degree from the University of Maine in 1951, a bachelor of science degree in aeronautical engineering from the Air Force Institute of Technology in 1954, and was selected to fly the X-15 aircraft in 1958. He made the greatest number of flights - 34 - in the X-15 programme between 4 November 1960 and 1 July 1966. He attained his greatest altitude during his 14th flight on 27 June 1963 at 285,000 ft (86.9 km). He left the X-15 programme in 1966 to become Commander of the Air Force Flight Test Center at Edwards AFB, and was subsequently assigned to Kirtland Air Force Base as Commander of the Air Force Test and Evaluation Center. He is currently Vice-Commander, Aeronautical Systems Division, Air Force Systems Command, Wright Patterson Air Force Base, Ohio.

SMITH, Robert W. (Astro Designee)
Robert W. Smith was a Group 2 Astronautics course designee selected on 20 April 1962. At the time of his selection he was a 34 year old Captain in the USAF; born in Washington, he is married with two children. Prior to selection, he was stationed at Vandenberg AFB, California with the 6595th Aerospace Test Wing.

SORLIE, Donald M. (Astro Designee)
Donald M. Sorlie was a Group 2 Astronautics course designee selected on 20 April 1962. He is married with five children. Born in Omaha, Nebraska, he was a USAF Major at the time of his selection to the Aerospace course and stationed at Aeronautical Systems Division HQ, Wright-Patterson AFB, Ohio.

TAYLOR, James M. (MOL)
Lieutenant Colonel James M. Taylor, USAF was born on 27 November 1930, in stamps, Arkansas. He was married with three children. He received associate of arts degree at Southern State University of Michigan in 1959 and was selected for the MOL Programme on 12 November 1965 (Group 1) and when that programme was cancelled in June 1969 he returned to flight duty with the Air Force. He died in September 1970 in the crash of a T-38 Jet near Palmdale, California. At the time of his death Taylor was an Instructor at the Test Pilot School, Edwards AFB, California.

THOMPSON, Milton O. (Astro Designee, X-20 Dyna-Soar, X-15)
Civilian test pilot Milton O. Thompson was born on 4 May 1926 in Crookston, Minnesota and is married with five children. He flew as Navy pilot during World War 2 in the Pacific theatre, received a bachelor of science degree in engineering from the University of Washington in 1953 and was selected for the USAF astronautics course on 15 March 1962 (Group 1) as a Pilot Engineering Consultant. He was named as one of six pilots for the X-20 programme on 20 September 1962, the only civilian selected for the programme. After cancellation of the programme in 1963 he transferred to the lifting body research programme as NASA's chief project pilot and made the first five free flights in the M2 in 1963, becoming the first man to fly a lifting body. On 13 June 1963 he was assigned to the X-15 programme and between 29 October 1963 and 25 August 1965 made 14 flights in the aircraft reaching his greatest altitude of 214,100 ft (65.3 km) on his last flight. In the fall of 1966 after leaving the X-15 programme to return to the lifting

body programme, Thompson became Director of Research Projects at NASA Dryden Flight Center, Edwards, California. He is currently Chief Engineer there.

TRULY, Richard Harrison (MOL, NASA)
Commander Richard H. Truly, USN, born on 12 November 1937 in Fayette, Mississippi, is married with three children. He received a bachelor of aeronautical engineering degree from Georgia Institute of Technology in 1959 and was selected for MOL on 12 November 1965 (Group 1). Following cancellation of the programme he transferred to NASA on 14 August 1969 (Group 7)[18].

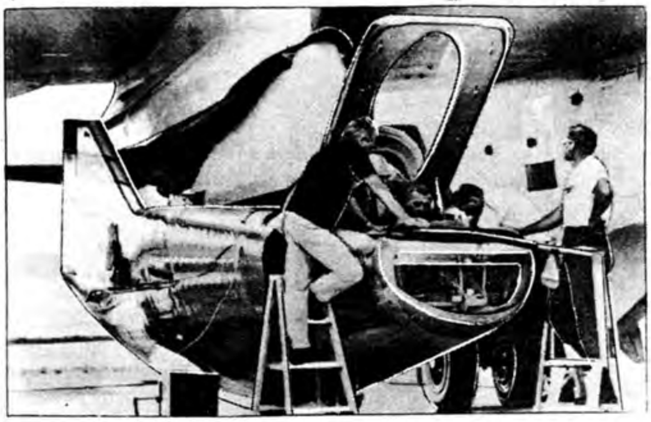
TWINTING, William T. (USAF Astro Designee)
Captain William T. Twinting was a Group 2 Astronautics course candidate selected on 20 April 1962. Born in Berwyn, Illinois, he is married with two children. At the time of his selection he was a 34 year old Captain in the Air Force stationed at HQ ADC, Ent AFB, California.

UHALT, Alfred H. (USAF Astro Designee)
Alfred H. Uhalt was a Group 3 Astronautics course candidate selected on 23 October 1962. Born in New Orleans, he graduated as a test pilot in 1958. At the time of his selection he was a 31 year old Captain in the USAF.

WALKER, Joseph Albert (X-15)
Joseph A. Walker, a civilian test pilot was born on 20 February 1921 in Washington, Pennsylvania and was married with four children. He received a bachelor of arts degree in physics from Washington and Jefferson College in 1942 and flew as an Air Force pilot during the Second World War. Selected for the X-15 programme in 1958, he flew the aircraft from 25 March 1960 to 22 August 1963. During his total of 25 flights he attained the greatest altitude in the X-15 programme on his last flight on 22 August 1963 when he reached 354,200 ft or 108 km, thus achieving the Astronaut rating. After leaving the X-15 programme in 1963 he became a Chief test pilot for NASA at Edwards AFB. He was killed on 8 June 1966 in the mid-air collision between the F-104 he was piloting and an XB-70. At the time of his death he was also engaged in test-flying the Lunar Landing Research Vehicle.

WHITE, Robert Michael (X-15)
Major General Robert M. White, USAF was born on 6 July 1924 in New York City, New York. He is married with four children. He received a bachelor of science degree in electrical engineering from New York University in 1951 and a master of business administration from the George Washington University in 1966. Selected for the X-15 programme in 1958 when he replaced the original USAF pilot for the X-15 programme, Ivan Klincheloe, who had been killed in an air crash, he flew the X-15 aircraft from 13 April 1960 to 14 December 1962 for a total of 16 flights. He attained his greatest altitude on his 15th flight on 17 July 1962 when he attained the greatest height in the X-15 programme by flying to 314,750 ft (95.9 km) thus attaining the Astronaut title. He left the X-15 programme following his flight in December 1962 and returned to flying duties in the Air Force. He is currently Chief of Staff, 4th Allied Tactical Air Force, Ramstein Air Base, West Germany.

WOOD, James W. (USAF Astro Designee, X-20 Dyna-Soar)
Colonel James W. Wood, USAF (Retd) was born on 9 August 1924 in Paragould, Arkansas, and is married with three children. He received a bachelor of science degree in aeronautical engineering from the Air Force Institute of Technology in 1956 and was an experimental flight test pilot at the Air Force Test Center when selected for the USAF Astronautics course on 15 March 1962 (Group 1). He was selected for the X-20 Dyna-Soar programme on 20 September 1962 and when the programme was cancelled in 1963 he returned to the Air Force on active flight duty. He held several positions until his retirement in 1975. His last appointment was as Commander, Test Operations, Edward AFB, California.



Test pilot Milton Thompson checks out instruments of the M2-F2 powerless lifting body vehicle before its first flight at Edwards Air Force Base, California.

NASA

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JUPITER C/JUNO I – AMERICA'S FIRST SATELLITE LAUNCHER

By Andrew Wilson

Introduction

America's first large missile was the Redstone, born out of the Hermes project and drawing on its builders' experience with the V-2. The US Army's base at Redstone Arsenal in Huntsville, Alabama was asked to conduct studies for a 500 miles range missile but as the design took shape its capability was reduced to 200 miles. In 1952 the first prototype of Redstone was delivered and in June 1953 Chrysler was awarded the prime contract for missile production.

The first test flight, on 20 August 1953, was generally encouraging and over the next five years 37 test flights were made before Redstone was declared to be operational. Redstone's configuration evolved during these flights to produce a missile 70 in in diameter, 69 ft long and weighing about 61,000 lb, powered by an engine based on the Navaho propulsion system and using lox and alcohol-water propellants. The 75,000 lbf engine burned for 121 s.

NATO deployed Redstone in Europe in 1958 but it was replaced by the Pershing in the early 1960's. Its fame arose out of its subsequent career as a space launcher.

Twenty five of the 37 test flights were used to check out components for the Jupiter missile, also under development in Huntsville at the time. These Redstones were tagged with "Jupiter A" labels and when a later, higher-performance version was designed it was named the "Jupiter C" ("C" for Composite). This vehicle was ostensibly intended for Jupiter re-entry tests but, in fact, it became the rocket which was to take America into the space age.

Background

The launch of Sputnik 1 on 4 October 1957 left America in a state of shock and both the public and politicians demanded to know the reason why the Russians had reached orbit first. Vanguard was still a considerable time away from its first orbital attempt but two tests had been successful the previous December and May while another was scheduled for late October. The first orbital attempt came with Vanguard TV-3 during 6 December 1957 and, strictly, it was another test, with the orbiting of a satellite as a secondary objective. Unfortunately, it was built up by the media as America's reply to Sputnik. In line with the civilian aspect of Vanguard, the preparations and launch were subjected to full public scrutiny and when the vehicle collapsed on its launch pad at Cape Canaveral there was no way of hiding it from the world. It was a massive failure for Vanguard but had it succeeded the history books recording the start of the space age would perhaps read very differently. The failure opened the way for the Jupiter C rocket to orbit America's first satellite, something that Von Braun and the Army had been fighting to achieve for a long time. Had General Medaris, chief of the Army Ballistic Missile Agency (ABMA) in Huntsville, been given permission in 1956 for an orbital launch with the Jupiter C, the US would almost certainly have beaten the Soviets.

Origins of Jupiter C

Alexander Satin and George Hoover of the ONR (Office of Naval Research) were interested in orbiting a minimum satellite, an interest owing not a little to the "Minimum Satellite Vehicles" paper of Gatland, Kunesch and Dixon of September 1951[1, 2]. The Army in Huntsville was asked if a Redstone would be available to act as a booster, and in June 1954 a conference held in Washington, D.C., with von Braun, Durant, Whipple and Singer in attendance concluded that a Redstone with upper stages consisting of 31 Loki solid propellant rockets could take a 5 lb satellite into a 200 mile orbit. The time was right for pressing satellite projects because the IGY (International Geophysical Year), intended to cover 1957-58, was then under planning and looking for candidate projects. On 4 October 1954 the planning body officially recommended that a satellite be considered by participating nations. The Redstone/Loki proposal had turned into Project Orbiter, with the Army at ABMA providing the booster and the Navy providing the payload.

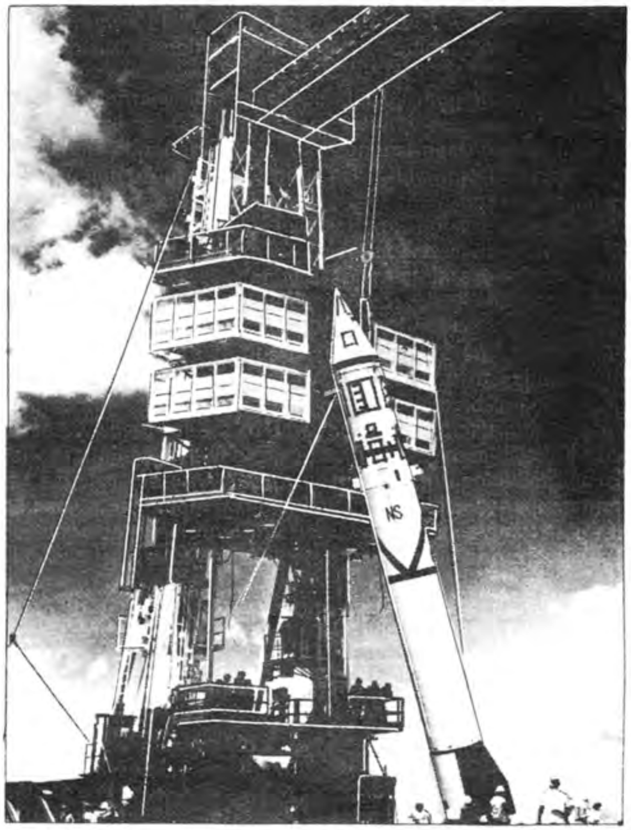

Fig. 1. Redstone "NS" (35) was launched on 12 July, 1957 as part of the development test programme. The flight was normal during the powered and coast phases but problems arose when the control system (housed in the section above the air vanes visible in the picture) malfunctioned during re-entry.

US Army

Although Orbiter originated with ONR in 1952/3, the entry of the Army eclipsed their contribution because the rocket was Army-supplied. After that, the project was usually been regarded as belonging to the Army, who did little to dispel the notion.

Some contracts had even been let by the end of 1954 but clouds were on the horizon for Orbiter because the Naval Research Laboratory (NRL) was formulating its own proposal. They pointed out that Orbiter had a low injection altitude, poor guidance, unreliable upper stages and primitive tracking techniques once in orbit – in other words, it was a minimum project with little room for scientific research. The NRL proposal put forward a much larger satellite than the 5 lb Redstone payload, and launched by a vehicle based on the Viking sounding rocket.

Both the US and USSR adopted satellite projects for the IGY and the two main US proponents had to fight it out. Orbiter's design changed over from Loki-based upper stages to a design based on scaled-down Sergeant motors. The scheme called for eight such vehicles to be built but the NRL still had the larger satellite. Vanguard, as the NRL proposal became to be known, was more flexible, largely a civilian project and its development would not interfere with missile work going on at Glenn L. Martin, the builders of Viking. On the other hand,

there were a lot of unknowns to be overcome because the vehicle still had to be developed. Orbiter/Redstone could rely on off-the-shelf components for the first stage and a relatively simple design for the upper stage but it was very limited in what it could achieve. The proposals* were placed before the Stewart Advisory Group on Special Capabilities for a decision on 3 August 1955. They voted in favour of Vanguard but the arguments continued because the Army was so vehement in defence of their own proposal. Looking back with hindsight, we can see the basic differences between the two: Vanguard was more flexible with the promise of greater scientific results while Orbiter was the "get-there-first" project with limited possibilities. Beating the Russians was not so important in 1955 – except, perhaps, to the military – so we should not be too surprised that Vanguard was the victor, even if it was much riskier.

The arguments went on. The Army claimed Orbiter had not been considered properly because all the facts had not been before the committee. An Army memorandum of 15 August 1955 said that replacing the 75,000 lbf engine of Redstone with a 135,000 lbf version would result in an orbital flight by August 1957 and would allow 100 lb payloads to be sent to the Moon. Orbiter would still be less risky than Vanguard. It was all to no avail because a second review by the Advisory Group again voted in favour of Vanguard and the armed services were notified on 9 September 1955 that the Navy would be handling the project.

Nevertheless, Jupiter C was still built. The ABMA was developing the Jupiter missile at the time and research had to be done into the protection of vehicles re-entering the Earth's atmosphere. In the 1950's, the best method of protection still had to be evaluated for application to the missiles then under development (Atlas, Titan, etc) since ground-based experiments, such as wind tunnel investigations, could provide only part of the necessary information. Two main methods eventually emerged, each with its own supporters. The blunt heat sink body developed by H. Julian Allen at the Ames Laboratory was favoured by the Air Force, while the ablative approach, although more difficult to achieve, was favoured by the Army. We know now that the ablation method became dominant.

The warhead of Jupiter was no exception to the problems of re-entry and flight investigations were deemed necessary to supply the answers. Jupiter had a higher development priority than the lower range Redstone and General Medaris, to prevent the test vehicles being starved of money, named them Jupiter A and C. Authorisation came through to fire twelve Jupiter C's as part of the nose-cone development programme and it was fortunate for the Army in later years that the vehicles were identical to the Orbiter proposal.

Rocketdyne, the builders of the propulsion system, suggested a switch over to "Hydyne" fuel (60 per cent unsymmetrical dimethylhydrazine and 40 per cent diethylene triamine) which would push the thrust up from 75,000 lbf to 83,000 lbf without needing extensive engineering changes. At the same time, tankage length was increased by 8 ft to increase the burn time from 121 s to 155 s. This required the addition of another hydrogen peroxide tank to keep the turbopump running for the extended burn time. Major physical changes included tapering down the instrument section at its forward end to fit the upper stages and measures to reduce vehicle weight were taken by reducing the skin thickness of containers, using a lighter design for the instrument section and employing springs instead of pneumatic cylinders to achieve booster separation.

The first firing of Jupiter C came on 20 September 1956 from Cape Canaveral in a bid to test the vehicle itself. No nose-cone test material was carried. The Redstone chosen was number 27, identified by the "UI" painted on its side. Redstone and its early derivatives used a unique system of identification

Launch	Missile	Letter Code	Launch Date	Comments
1	27	UI	20. 9.56	Jup. C test, UE backup
2	34	NT	15. 5.57	Nose-cone test
3	40	TX	8. 8.57	Nose-cone test
4	29	UE	31. 1.58	Explorer 1
5	26	UV	5. 3.58	Explorer 2. UT backup
6	24	UT	26. 3.58	Explorer 3
7	44	TT	26. 7.58	Explorer 4. TI backup
8	47	TI	24. 8.58	Explorer 5
9	49	TE	22.10.58	Beacon 1

based on the missile number and the name "Huntsville". Each letter in the name was awarded a number:

H U N T S V I L (L) E
1 2 3 4 5 6 7 8 9

Thus missile 27 carried the letters "UI" and Explorer 1's launcher, missile 29, was known as "UE". Zero was represented by an "X", as in "TX" for missile 40. Table 1 gives the complete Jupiter C/Juno I launch list, together with the missile numbers and letter codes. The satellite launcher was called Juno I, although there is frequently no distinction made between the two versions in most texts.

The night firing of "UI" resulted in a range of 3,000 miles and an altitude of 600 miles being reached, the greatest of any US rocket at that time, and it gave the Army team the confidence that Jupiter C was a sound vehicle. It also convinced Medaris that he had a vehicle capable of orbiting a satellite and he ordered the backup rocket for that night, missile 29

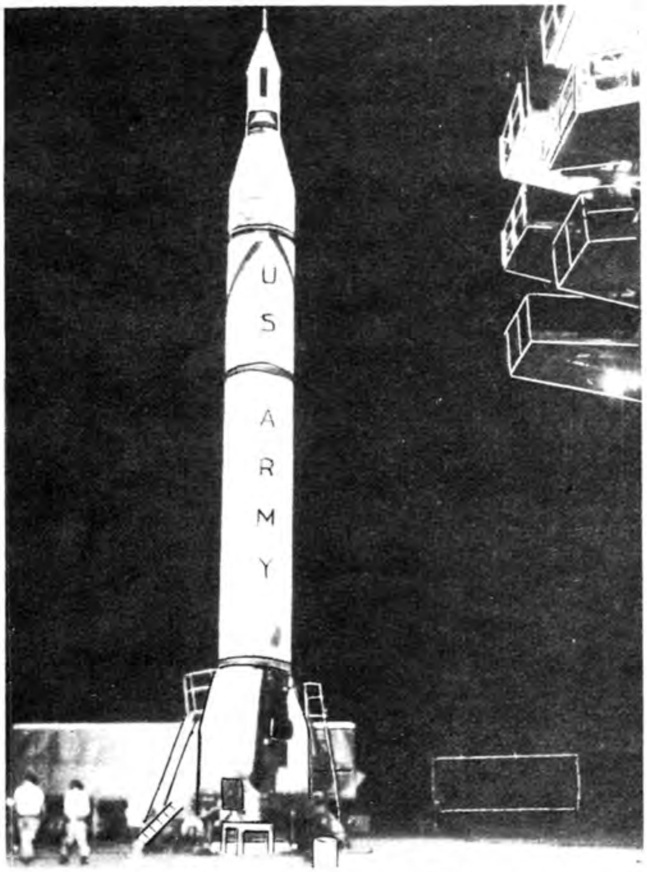

Fig. 2. On 8 August, 1957, Jupiter C "TX" flew the final mission in the re-entry test programme. The last stage can be seen to be slightly different from the satellite version and the Redstone body still bears the "US ARMY" lettering.

US Army

* *The Air Force put forward a third proposal, utilising their Atlas booster, which would have been on a much longer time scale.*

(UE), to be put back into storage, perhaps destined for greater things. The flight record stood unacknowledged because the project was top secret and few realised that if sand ballast in the fourth stage had been replaced by propellant a satellite could have been put into orbit.

The first reduced-scale nose-cone was fired aloft by Jupiter C number 2 (Redstone 34) on 15 May 1957, just two weeks before the first full Jupiter missile firing and indications were that everything had gone well but the nosecone was never recovered from the Atlantic. It was suggested that sharks had punctured the flotation bag and, accordingly, the amount of shark repellant was increased for the next flight. To finally prove that the ablative system was adequate for protecting missiles' nosecones the Army had to recover the test material from a Jupiter C flight. Launch number 3 provided them with the answers when Redstone "TX" boosted its payload into the skies during the early morning hours of 8 August 1957. Flares released from the rocket helped to establish the trajectory and a recovery team was homing in on the returned test material even before the sofar bombs had detonated. A radio beacon and a brilliant yellow flotation balloon aided in the recovery. Examination of the material proved the ablation concept to be sound and Medaris terminated Jupiter C's series of test flights. In a directive of 21 August 1957 he ordered remaining hardware to be put into protected storage. Vehicles were in various stages of production but Medaris had his eye on two of them, with a view to using them as satellite launchers. He advised General Gavin (chief, Research and Development of the Army) that these two vehicles could be held for launches four and five months after the go-ahead was given. The order came after Sputnik 1 had already stolen the limelight.

The go-ahead is given

When news of the Soviet achievement reached the Americans, Medaris, von Braun and the Secretary of Defense-to-be McElroy were at a reception in Huntsville. Von Braun pleaded with McElroy for permission to launch a satellite, with only a 60-day delay necessary. Medaris interrupted with a correction of 90 days and McElroy was interested. The Army pair worked on him for the rest of the evening but McElroy could give no firm commitment. Nevertheless, Medaris soon instructed von Braun to take "UE" out of storage and start work on it, convinced that permission would be received in the next few days. When it was announced by the Pentagon on 8 November (after Sputnik 2 had been orbited) it read:

> *"The Secretary of Defense today directed the Army to proceed with launching an Earth satellite using a modified Jupiter C".*

Medaris soon spotted that the request regarded Jupiter C as a backup to Vanguard and he continued the fight to be given a firm commitment for two attempts. He had it after Vanguard TV-3 exploded on 6 December 1957.

"UE" and its backup were taken out of storage from the Fabrication Laboratory, where they were built, at ABMA and brought up to flight standard. The checks had largely been completed when a C-124 Globemaster aircraft brought "UE" to Canaveral on 20 December. More work followed and on 17 January the booster was hoisted to the vertical on pad 26A where it stood on a four-legged steel table with a conical flame deflector beneath its engine. The Firing Laboratory of ABMA took charge once the vehicle was at Canaveral and a week after rerection the upper stages were installed, although the igniters were left out. These were brought in from a storage area soon before the gantry was rolled back and installed by one man, with all radio transmitters in the area turned off for safety.

The upper stages were needed, of course, to provide the final energy necessary to attain orbit but in those days there were very few motors available to do the job reliably. Since reliability was the keyword, a series of small solid-propellant motors was chosen which saw service not only on the Jupiter C/Juno I but also aboard the later, higher performance Juno II.

The upper stages, provided by the Jet Propulsion Laboratory (JPL), can be considered to consist of four main components:

1 . . .the 11 motors of stage 2;

3 . . .the 3 motors of stage 3;

4 . . .the 1 motor of stage 4.

Since a solid motor could not be relied upon to perform in exactly the same way as others of its type, the whole assembly was spun up to a maximum rate of 750 rpm during flight to smooth out any irregularities in thrust. Although it was designed to provide the necessary directional accuracy, the spin presented problems of its own. The 11 stage 2 motors were distributed circumferentially inside the drum and a spin of 750 rpm subjected them to an acceleration of some 300 g! The propellant grain thus had to be able to withstand the extreme forces without cracking or burning unevenly and tests on the ground proved that it could if care was taken during the casting process.

The spin rate also meant that a careful programme of dynamic balancing had to be carried out. The outer drum was balanced on a spin-table by itself and, if necessary, small weights were added to balance it up. The stage 2 motors were then added and the combination spun up and adjusted as necessary. A similar process was followed for the addition of stages 3 and 4.

The motors chosen were scaled-down Sergeants ("Baby Sergeants") about 4 ft long and 6 in in diameter, mounted in bulkheads inside the tub. The tub also had a base plate and a central hollow shaft with a ballbearing mount attached to the booster to provide the rotational axis. Spin had to be carefully controlled throughout flight by a preprogrammed spin regulator so that the spin frequency did not excite the booster resonance frequency which changed as fuel flowed out. Initial spin-up was at 550 rpm and after booster burnout it had to be held to a steady 750 rpm because any changes would have overtaxed the roll control system by forcing it to counteract the reaction torques. At T+70s the spin increased to 650 rpm and at T+115s it was switched up to its full 750 rpm. Energy for the spin came from two 28 V, 2.6 kW aircraft electric motors run in parallel and connected to the central shaft. To save weight they were frequently overloaded but experience showed that they were capable of taking the strain.

The three stage 3 motors slotted into the central hole of the bulkheads holding the eleven stage 2 motors and were held by three supports 120 degrees apart which were used for adjusting the relative position of the two stages.

The stage 3 motors, like those of stage 2, were held in position by three bulkheads and a conical aluminium shell was attached to the forward end for supporting the lone Sergeant of stage 4. Three holes cut into the shell allowed exhaust gases to escape at stage 4 ignition and permitted engineers on the ground to insert the motor igniter. A 1.5 in diameter cylinder ran the length of stage 3 along the centreline to carry batteries and timer equipment for upper stage ignition. The upper stages and instrument section remained attached to the Restone until about five seconds after booster shutdown. Small powder charges in six bolts were then fired and springs coiled around the bolts pushed the booster away at about 2.6 fps. The instrument section tilted over to the horizontal to direct the upper stages onto the correct heading, waiting for the trajectory's apex to be reached and a signal from the ground to send the payload on its way into orbit. After the initial signal had been received the timer took over.

The first attempt at launching "UE" was scheduled for Wednesday, 29 January 1958 after the needs of Vanguard had

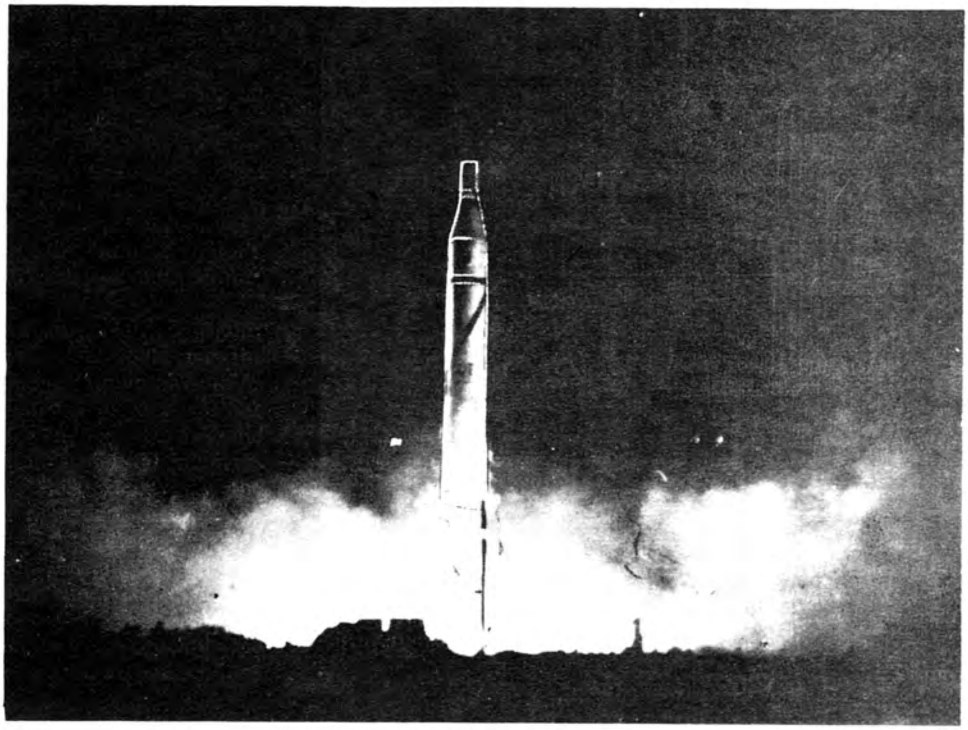

Fig. 3. "UE" lift off on the night of 31 January, 1958 sent Explorer 1 into orbit and took America into the space age.

US Army

been satisfied since the two projects had to use common services at the Cape. Vanguard was slated for a January flight but delays forced it into February. If the Jupiter C failed to go at the end of January the next attempt was scheduled for 5 March.

The most important individual at the launch was Dr. Ernst Stuhlinger because it was he who had to calculate in four minutes the time when the upper section had reached its apex ready to release the higher stages. Weight limitations meant that there was little room for instrumentation and by today's standards the computations were primitive but Stuhlinger expected to press the firing button at about T+400s after the instrument section had rotated to the horizontal. Then there would be a long wait until tracking stations reported satellite acquisition - if everything had gone well. Later launches became more sophisticated. Data from radar, the accelerometer aboard the vehicle and Doppler tracking were fed into a small computer to calculate the second stage firing time. A clock was then set to automatically send the ignition signal. In fact, second stage ignition had to occur slightly before apex so that fourth stage burnout would be at that point.

A good deal of uncertainty crept into the flight because the method of booster shutdown was crude, thereby making it difficult to predict where the apex would lie. Pressure sensors in the fuel and lox lines watched for a pressure drop which would mean either or both propellants were about to run out. When this drop was detected propellant flow from both sources was shut off.

Pressmen were officially told about the flight 24 hours beforehand but on the 28th a jet-stream moved south over the Cape and worries increased that the launch would have to be scrubbed. From the ground it appeared that the day was fine with blue skies overhead but the 175 knot airstream could have quite easily torn the Juno I apart and structural engineers at ABMA advised against a launch. The next day saw the winds still above Canaveral but at noon Medaris directed the eight hour countdown to begin. The winds stubbornly stayed where they were and at 8.20 p.m. a hold was called just before lox was poured into the tanks so that wind data could be analysed by the Computation Laboratory at ABMA. Again the launch was scrubbed. Friday, 31 January was probably the last chance for a while because the Vanguard launch was

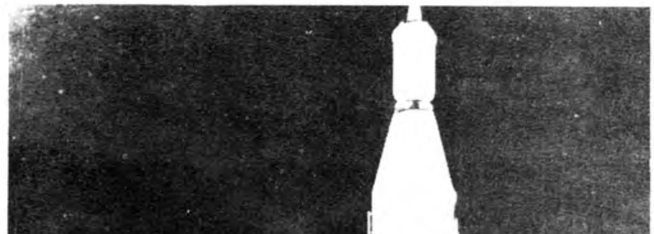

Fig. 4. Final preparations for the "UE" launch at Cape Canaveral. The Explorer 1 satellite is attached to the fourth stage motor in the spinning tub above the cone-shaped nose of the "stretched" Redstone. Instrumented by Dr. James A. Van Allen, it was to make the major discovery that the Earth is girdled by radiation belts.

US Army

getting uncomfortably close, but the winds were still there. However, the forecast saw a chance of them dropping to an acceptable value by the time launch came around. Medaris started the count at 1.30 p.m., aiming for a 10.30 p.m. launch, with a one hour leeway for any stoppages. Fuelling began at T−7hrs (the Army used the "X" system in its countdowns). The first hold was called to allow some members of the launch crew to catch up with their schedule and at 9.45 p.m. a second hold was called when hydrogen peroxide was spotted leaking from the base of the rocket. It turned out to be excess fuel in a flexible fuel line and was easily fixed. Previously, the upper stage igniters had been inserted, the range safety destruct package armed and the service tower rolled back some three hundred feet to clear "UE" for launch. At T−12s the upper stages began to spin up to 550 rpm and power was switched over to internal sources. Lift off came at 10.40 p.m. and "UE" lifted into the night sky with the Redstone consuming 50 gallons of propellant every second. By T+155s the vehicle had tilted over to 40 degrees above the horizontal. The booster burned out at T+157s and an altitude of 60 miles, and the instrument section separated and began to turn to the horizontal using its four 5 lbf air jets. On the ground, Dr. Stuhlinger quickly calculated the time to initiate stage 2's burn and, at T+404s, he pressed the button to send the radio command to stage 2's igniters. "UE" had taken slightly longer to reach apex than had been expected because burn out velocity had been a little low but once there the second stage ignited its Sergeant motors for a 6s burn at a total thrust of 1500 lbf. A 2s coast period followed and then the three motors of stage 3 ignited and followed the same pattern. Finally, the lone Sergeant below the payload itself lit up and burned for 6s. The waiting launch team had no clue as to the vehicle's performance in the latter stages because of the lack of instrumentation and they would know the result only if Explorer 1, as the satellite package was now called, was picked up in orbit. Medaris was talking to pressmen when an aide came forward with a piece of paper carrying the words "Goldstone has the bird!" – meaning that the Goldstone tracking station in California had picked up Explorer 1 as it passed overhead on its way to Florida to complete its first orbit.

Explorer 1 was made up of the remains of the fourth stage motor with an instrument compartment at the forward end, weighing a total of 30.8 lb and measuring 80 in long. The instrument section was made of 0.025 in thick steel with its outer surface sandblasted and coated with aluminium oxide stripes to provide temperature control. The minimum instrumentation included two small transmitters and equipment for temperature measurements, micrometeoroid impact detection and radiation measurements. The radiation experiment was expected to give counts of 30 to 40 pulses/s but at heights greater than 600 miles (the initial orbit ranged from 225 miles to 1584 miles) it became saturated. The Van Allen belts, named after the experimenter, had been discovered. Unfortunately, a lot of data were lost because the satellite did not carry a tape recorder. The discovery, though, dictated the trend of the later Juno I/Explorers; for example, Explorer 4 carried four experiments dedicated to radiation measurements.

The fourth stage to which the instrument section was attached was slightly different from the lower solid stages. Since it used a single motor centred on the spin axis it did not suffer the same problems as stages 2 and 3 and JPL was able to give it a slightly better propellant. By the time this propellant became available for stage 3 a high yield material had been adopted for stage 4, explaining why Explorer 4 was 7 lb heavier than its predecessors.

America was suitably satisfied that an answer, *albeit* a lightweight one, had been given to Sputnik and the people of Huntsville, especially, celebrated the event. Medaris, von Braun and the Army must have felt elated that Project Orbiter, scrapped in favour of the riskier Vanguard programme, had finally been vindicated in such a spectacular fashion. We can

Fig. 5. Engineers attach the instrument package to the fourth stage motor and the rest of the spin tub before the whole is mated with the rest of the vehicle. The fourth stage igniter was installed using the two holes just visible by the feet of the man standing on the tub.

US Army

only guess at the feelings of the Vanguard personnel at that time. To make matters worse, Explorer 1 was actually a Vanguard experiment modified to fit Juno I's requirements. Even worse, Vanguard TV-3BU failed to orbit its payload a few days later on 5 February. It was not until 17 March that Vanguard TV-4 sent Vanguard 1 into orbit.

Before Vanguard 1 made its way into the heavens, Juno I "UV" took aloft Explorer 2 on 5 March 1958. For some reason, the final stage motor did not ignite and extensive ground tests failed to show the cause. The motor's igniter was possibly defective and if this was the case then the vehicle itself was not at fault. Vibration and spin could have shaken the igniter loose from its mount in the fourth stage nozzle. Note that although it failed to reach orbit, the payload is recorded in launch tables as Explorer 2; this was before the practice of naming only successful payloads was adopted.

The backup payload and launch vehicle ("UT") for Explorer 2 were launched during 26 March and Explorer 3 entered orbit. An elevation error during upper stage burn resulted in the orbit being more elliptical than planned but it did not seriously affect the experiments. Explorer 4 with "TT" was also successful but Explorer 5, using Explorer 4's backup Juno I failed. Everything appeared to be going well with the flight until shortly after separation of the booster. Somehow it caught up with the upper sections, possibly because of incomplete engine shutdown or venting from the tank, and struck it. The impact was enough to permanently disturb the control system and when stage 2 ignited the cluster was pointed down and to the left of the required path. Retrorockets were installed to slow the booster down in future flights.

By this time, Juno I was becoming obsolete and it was almost ready to yield to the more powerful Juno II which, however, still used the same type of upper stages. Juno I still had one

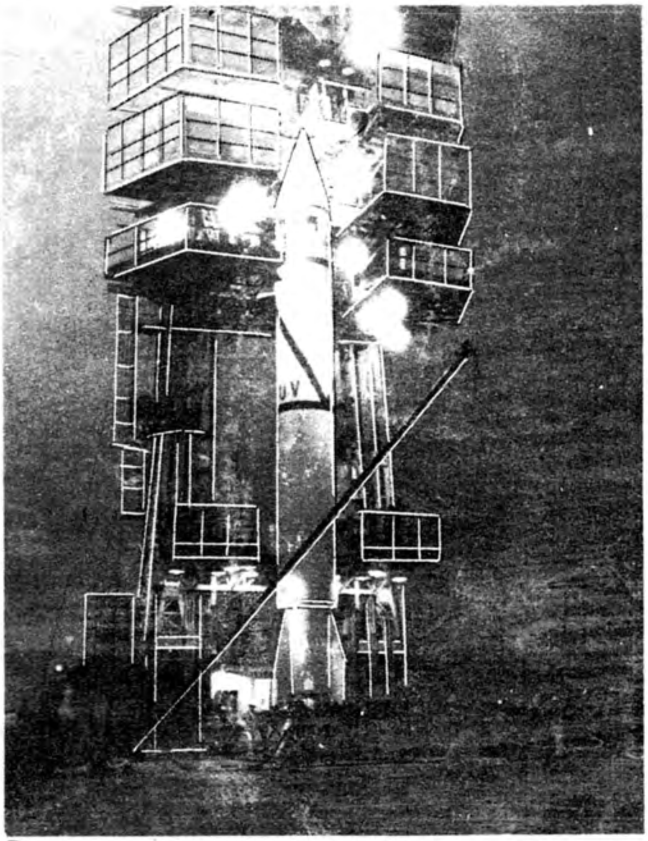

Fig. 6. "UV" on the pad with its forward end covered and awaiting the spin tub and payload for launch on 5 March, 1958.

US Army

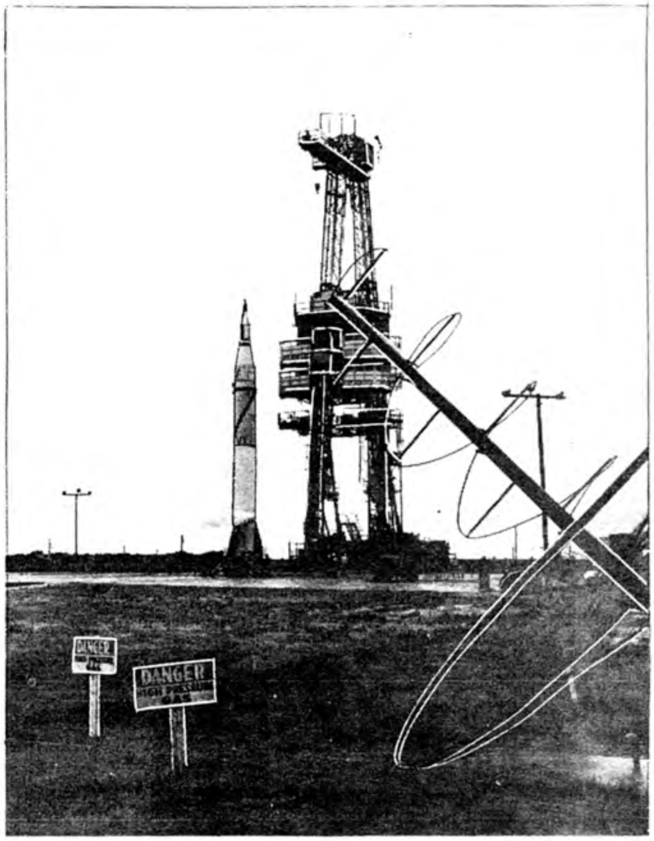

Fig. 7. "UT", as backup to "UV", took Explorer 3 into orbit on 26 March, 1958.

US Army

mission to fly – to launch the 12 ft diameter inflatable balloon Beacon 1, precursor to the giant Echo and Pageos balloons. Unfortunately, failure struck again.

This third failure was, again, hard to explain because of the lack of instrumentation aboard the vehicle. Accelerometers showed vibration beginning to build up after T+90s and the spin rate began to drop rapidly. The payload and fourth stage motor probably then broke away at T+149s and a minute later the rest of the cluster broke up. Suggestions for the cause included cluster resonance, excessive aerodynamic heating and a spin-induced failure in the payload structure. Aerodynamic heating had long been recognised to be a problem and the later Juno II carried an aerodynamic shield but weight restrictions had precluded any such shield on Juno I.

Beacon carried a small fifth stage attached to its forward end with the intention of firing it at first apogee. This would have raised the perigee and given the balloon satellite a relatively long lifetime.

Conclusions

Although Juno I saw only six launches and three successes it contributed a great deal to the beginning of the Space Age, providing a sound base for the second generation launchers to build on. The three small Explorer satellites provided information on the near-Earth space environment far in excess of their experimenters' hopes and their own sizes.

Visitors to the National Air and Space Museum in Washington, D.C., can see one of the unused Jupiter C/Juno I vehicles painted to represent the "UE" Juno I.

Acknowledgements

The author would especially like to thank David Harris and Ralph C. Perrill of the Redstone Arsenal Public Affairs Office for their help in the preparation of this article, and Mr. L. J. Carter for the loan of the photographs.

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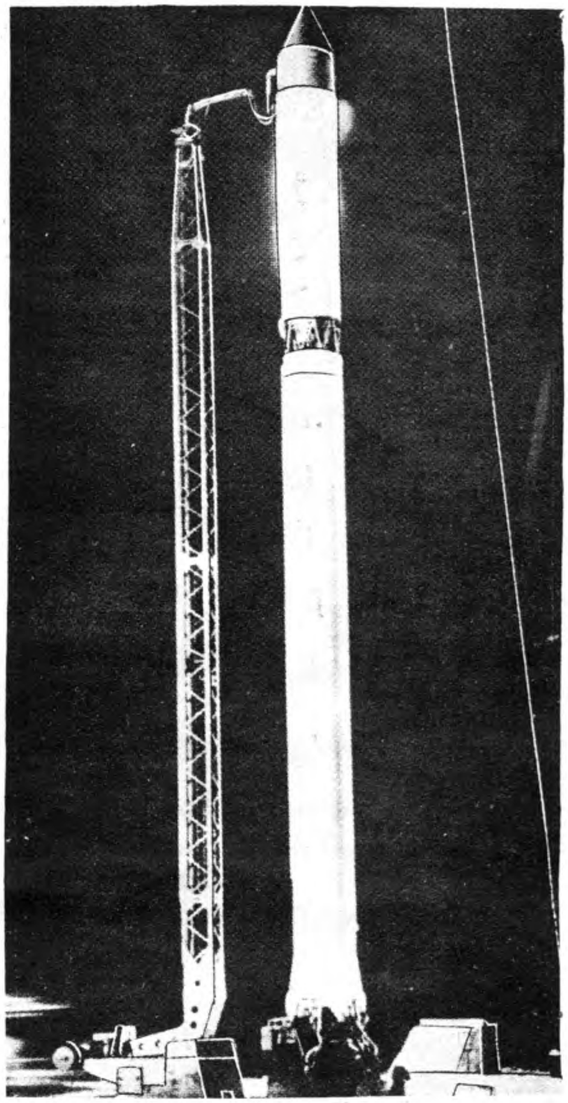
THE SANDAL PROGRAMME

By Phillip S. Clark



Novosti Press Agency

Introduction

When the first Cosmos satellite was launched on 16 March 1962 a new small launch vehicle was introduced which was based on the Soviet SS-4/Sandal vehicle. Previously all the Soviet orbital launches had used the SS-6/Sapwood derivative launch vehicle, flown from Tyuratam, while the Sandal vehicle introduced the small launch site of Kapustin Yar to orbital flights. While it was flown operationally the Sandal made a total of 144 orbital launches until it was retired in 1977 after the launch of Cosmos 919. The missions flown by the Sandal vehicle now use the more versatile SS-5/Skean vehicle.

A review has already been published covering the Sandal launches from Plesetsk into orbits inclined at 71° [1] and therefore in this article these flights will only be mentioned in passing. A total of 72 Sandal flights were made at 71°, exactly 50 per cent of the missions, with 60 flights going from Kapustin Yar at 48°-49° to the equator and the remaining 12 flights being Plesetsk launches into orbits inclined at 81.9°.

Table 1 provides a summary of the annual launches made into each inclination slot.

The Launch Vehicle

After the successful flights with the SS-16/Sapwood launch vehicle in the early days of the Space Age the Soviets wished to launch small satellites for scientific and military missions, but the use of the large Sapwood for these missions would have been a case of overkill. The Soviets looked to other elements of their missile arsenal for the basis of a smaller satellite launcher. They chose to develop the SS-4 missile with the NATO code-name "Sandal" for the small satellite launch vehicle, and added a second orbital stage to the missile. The complete assembly, when revealed in 1967, was named the "Cosmos Rocket", and is the "B-1" in Dr. C. S. Sheldon's classification of launch vehicles.

The various statistics pertaining to the Sandal launch vehicle are given in Table 2. The first stage has a length of 19.7 m and a principal diameter of 1.65 m. At the base the engine mount, with a length of 1.8 m, expands to a diameter of 2.26 m. The engine extends into a section some 2.3 m long, above which is the main 15.2 m fuel tank area.

Table 1. Number of Sandal Orbital Launches.

Year	Kapustin Yar 48.4°	48.8°	49.0°	Total	Plesetsk 71.0°	81.9°	Total	Launch Total
1962			7	7				7
1963			4	4				4
1964			7	7				7
1965	3	4		7				7
1966	5	1	1	7				7
1967	6	1		7	4	2	6	13
1968	8			8	6	2	8	16
1969	4			4	9	1	10	14
1970	5			5	10	3	13	18
1971	1			1	10	1	11	12
1972	2			2	9	1	10	12
1973	1			1	8	1	9	10
1974					6		6	6
1975					4	1	5	5
1976					4		4	4
1977					2		2	2
Total	35	6	19	60	72	12	84	144

Atop the first stage is an open truss framework, reminiscent of the Sapwood rocket, which extends for 1.2 m. The second stage has a length of 6.74 m with the single engine nozzle protruding 0.8 m below the base of the rocket body. The second stage has a constant diameter of 1.65 m. The payload shroud consists of a cylinder, 1.0 m long and 1.65 m in diameter, topped by a cone with a length of 1.75 m [2].

The first stage of the launch vehicle is powered by a single RD-214 engine, which seems to be a close relative of the RD-107 and RD-108 engines which power the first stage of the Sapwood rocket. There are four nozzles with no verniers. The engine burns kerosene and nitric acid: it has a base diameter of about 1.8 m and a height of 3.3 m. Although the Sandal missile has four base fins when trundled through Moscow on display, the modified version used for orbital launches seems to be without fins.

The second stage of the Sandal uses a single RD-119 engine with a single main nozzle and four smaller vernier nozzles. The RD-119 burns UDMH and (probably) liquid oxygen. The main chamber of the engine has a base diameter of 0.8 m and a height of 1.9 m.

In 1976 *Aviation Week & Space Technology* reported that the Sandal vehicle was launched from a silo [3], although the Soviets have denied this. The pictures released of the second stage being handled at Kapustin Yar certainly suggest that it is being placed on top of a missile in a silo and the only picture released of the Sandal at Kapustin Yar shows the complete vehicle in flight. Certainly the vehicle is not silo-launched from Plesetsk, since a picture has been released showing the Intercosmos 8 vehicle on the launch pad.

Table 2. Sandal Launch Vehicle Data.

	Stage 1	Stage 2
Length, m	19.7	6.7 (Inc. nozzle, 7.5)
Diameter, m	1.65	1.65
Empty mass, kg	4000*	1500*
Fuelled mass, kg	30000*	13500*
Vacuum Isp, sec	264	352
Thrust, tonnes	74	11

Total length 30.0 m (Interstage 1.2 m, Shroud 2.75 m).
Total mass 43800–44180 kg (Shroud 150 kg).
*Estimated data.

Table 3. Summary of Sandal Payloads.

Site	Incl °	Period min	Altitude km	Mass kg	Flights
KY	48.4	90.0	245– 300	530	149*, 320*
		91.0	250– 400	510	215*, 335*
		91.7	215– 500	495	93, 95, 197, 202
		92.3	270– 500	480	106, 116, 123, 166*, 225*, 230*, *7**
		93.3	250– 625	455	135*, 163*, *1**, *4**
		95.2	260– 800	425	262*
		98.6	200–1180	375	*2**, *5**
		99.9	210–1300	340	119, 142*, 259*, *3**
		102.2	200–1525	310	*9**
		104.7	215–1745	275	219*
		108.8	215–2130	210	97*, 145, 221, 268, 307, 347, 501
	48.8	92.4	255– 525	475	76, 101
		95.5	225– 860	415	196*
		98.5	215–1160	370	53*, 70
		104.5	220–1720	275	137*
	49.0	90.8	265– 365	510	6*, 26*
		91.6	220– 490	490	31
		92.2	255– 510	475	14*, 19*, 25*, 36, 49*, 51*
		93.0	240– 605	465	8*, 23*
		93.8	215– 705	450	3*
		95.1	260– 790	425	17*
		95.4	220– 855	415	108*
		96.0	235– 900	410	11*
		96.4	205– 965	400	1*
		98.0	230–1100	370	42–43
		102.5	200–1550	305	2*, 5*
Pl	71.0	91.3	270– 405	385	(See Ref 1, 0 science flights)
		92.1	270– 485	370	(See Ref 1, 2 partial science flights)
		93.1	205– 645	355	(See Ref 1, 3 science flights)
		95.5	270– 815	310	(See Ref 1, 0 science flights)
	81.9	92.6	230– 575	300	356*
		102.1	200–1520	150	165, 176, 211, 233, 283, 319, 380, 408, 472, 601, 703

Notes: (1) The flights are grouped by launch site, orbital inclination and orbital period.
(2) Joint Soviet-Bloc *Intercosmos* flights are shown in italics. Other numbers are Cosmos missions.
(3) Scientific missions are followed by *.
(4) The 72 flights at 71° are reviewed in Reference 1.

Payload Capacity

Until recently, there seemed to be no official masses available of the Sandal-launched payloads. Sheldon estimated that the general capacity was within the range 260–425 kg, while reporting that Woods had obtained a range of 280–600 kg from Soviet officials [4]. More recently the writer's attention has been drawn to figures quoted in a Polish publication for the Sandal-launched Intercosmos flights, and these are given below:

Intercosmos 1	315 kg?	Intercosmos 2	$\dot{\sim}$320 kg
Intercosmos 3	340 kg	Intercosmos 4	~320 kg
Intercosmos 5	340 kg?	Intercosmos 7	375 kg
Intercosmos 8	340 kg?	Intercosmos 9	340 kg?

The use of "?" and "~" above follows their use in the Polish original [5]. Of the exact masses quoted, Intercosmos 3 had the largest launch delta-V and therefore this was used to scale the payload capacity of the Sandal to its other orbital "slots", the results being shown in Table 3. This suggests that the general payload range is about 150–530 kg.

Satellite Missions

When one compares the number of scientific missions flown from Kapustin Yar and Plesetsk using the Sandal it is clear that the Kapustin Yar site is used for more "civilian" flights. Of the 60 flights from Kapustin Yar, 40 have been tagged as being scientific, while only 4 of the 84 Plesetsk flights have been identified as having a primarily scientific purpose (plus Cosmos 321 and 481 which had supplementary scientific experiments). Table 3 indicates which of the flights have had a scientific purpose announced, and it is possible that some of the flights not identified as scientific may be science failures: for example, Cosmos 119 which remained attached to the second stage rocket body is the only flight of its sub-group not to have had a scientific mission revealed, so one wonders whether this might have been a science failure. A summary of the scientific missions flown by the Sandal-launched Cosmos satellites can be found in Ref 6.

The review of Cosmos 71° missions indicated that those flights were for some ill-defined military purpose, and it would seem that all we can do with the other military Sandal missions is leave the detailed clandestine mission with a question mark. Certainly, the Soviets are not likely to indicate the actual missions of the craft in the open press.

Kapustin Yar Flights

The initial flights of the Sandal vehicles were made at an orbital inclination of 49.0°, but in 1965 the first sign of a slight change in inclination came when Cosmos 53 was launched into a 48.8° orbit. After a few years overlap all the flights have been made into an inclination of 48.4°, which implies a virtual due east launch for the vehicle, giving the greatest launch assistance due to the Earth's rotation. This change is brought out in Table 1. The Kapustin Yar launch rate settled down to a virtually constant annual total of about 7 flights, with 1968 hitting a peak of 8 flights. The final orbital flight from Kapustin Yar of the Sandal was Intercosmos 9 (also called Copernicus-500) in 1973, the same year that the first orbital flight of the Skean was made from the site.

Calculations can be made to ascertain any ground track repetition patterns for the various satellites, and the results of the Kapustin Yar flights are given in Table 4. The second column of the Table gives the period in which the orbital ground track repeats, rounded to the nearest day. The third column shows the number of orbits between successive ground track repetitions and the fourth column shows the actual shift in the ground track over the period indicated by column 3. A positive value indicates a shift westwards and a negative value a shift eastwards. Although the satellites may be launched into

Table 4. Kapustin Yar "Repeater Orbit" Satellites.

Flight*	Interval Days	Interval Orbits	Longitude Shift°
149	4	63	0.9
320	3	47	−0.1
6	5	78	−1.3
26	2	31	−1.6
215	2	31	−1.1
335	2	31	−1.6
31	2	31	3.1
197	2	31	2.4
202	2	31	1.7
25	6	92	1.4
49	10	154	−1.7
76	6	92	−1.2
106	4	61	1.6
123	6	92	−1.4
166	4	61	1.6
225	6	92	−1.4
230	4	61	0.5
Ic 7	4	61	−2.0
8	4	61	2.5
135	8	121	0.1
Ic 1	12	182	2.2
Ic 4	8	121	0.7
17	1	15	2.6
262	1	15	2.9
108	1	15	3.6
196	1	15	3.9
{42	2	29	2.8
{43	2	29	1.7
53	3	43	−2.0
Ic 2	8	115	−2.6*
Ic 5	8	115	−2.3
142	1	14	−3.7
259	1	14	−3.6
2	1	14	3.3
Ic 9	1	14	2.9
219	2	27	−3.4
97	1	13	−1.2
145	1	13	−2.1
221	1	13	−3.1
268	1	13	−0.4
307	1	13	−0.8
501	1	13	−0.1

Notes: *Cosmos flights are identified by number, while Intercosmos flights are indicated by "Ic".

Owing to changes in our printing arrangements it has been necessary to defer for one month a number of articles previously advertised for this issue. The index to Volume 22 will appear in our March issue. Ed.

"repeater" orbits, the orbital decay results in the "repeater" not being maintained for any length of time.

Table 4 has the satellites grouped as in Table 3, with satellites which are not in "repeater" orbits being excluded. It is interesting to note that satellites in the same general group can have orbits which repeat over differing periods of time. For example, Cosmos 149 and Cosmos 320 were the same type of satellite - testing aerodynamic stabilisation in a low orbit - but the former repeated its orbit after 4 days and the latter after 3 days.

Orbital plane spacings were calculated for the flights in the same groups which were in orbit at the same time, and only two significant ones were noted. Cosmos 53/Cosmos 70 were about 90° apart, and Cosmos 211/Cosmos 233 were 45° apart. Of course, since the satellite orbits were in differing stages of decay the plane spacings were not maintained for long.

In concluding the Kapustin Yar section, two other launches should be noted. Cosmos 42/Cosmos 43 was the only dual payload carried by a Sandal, and the satellites might have been connected with the developing Skean programme [7]. Cosmos 119 remained attached to the final stage of the launch vehicle, and therefore might have been a scientific payload which failed (since the other flights in the small group have had scientific missions announced).

Plesetsk Flights

The vast majority of the Plesetsk Sandal flights have been to 71° orbits, and are therefore covered in Ref 1. Table 5 notes the ground track "repeater" satellites launched from Plesetsk.

The orbits for some Plesetsk missions have counterparts with a few earlier Kapustin Yar flights, so one is led to wonder whether some initial proving missions were flown from Kapustin Yar before operational flights began from Plesetsk. Certainly, it would seem reasonable to assume that the Cosmos 106-116-123 trio was in preparation for the operational flights from Plesetsk in the 71° Group B beginning with Cosmos 152.

While the Sandal was phased out from Kapustin Yar in 1973, flights from Plesetsk continued until June 1977 when Cosmos 919 ended the programme. Presumably the Soviets simply ran out of Sandal rockets, since there was no significant payload mass increase - at least for the Intercosmos flights - when missions were switched to the larger Skean vehicle.

Other Sandal Missions

Since a total of 144 launches made by the Sandal vehicle reached orbit, by the law of averages one would expect perhaps 15-20 launch failures to have taken place during its 15 years of operational use. No launch failures have been publically reported which can be identified with certainty with the Sandal. An Intercosmos launch failure from Kapustin Yar in 1975 has been equated with the use of the Sandal [3], although it would seem that the Skean was probably used for the flight [8].

Summary

The Sandal was the second launch vehicle which the Soviets introduced and it has become the first to be retired. It provided the Soviets with a launch system which could be used for small scientific and military satellites, the successors to which are now being used on the Skean rocket.

REFERENCES

1. Phillip S. Clark, " Cosmos Flights at 71°," *Spaceflight*, 22, p. 174 (1980).
2. Pavel Elsztein, *Polska v Kosmosie*, Wydawisictwa Komunikaiji i Laczenosci, 1978, p. 58.
3. *Aviation Week & Space Technology*, Apr 19 1976, pp. 40-41.

Table 5. Plesetsk "Repeater Orbit" Satellites.

Flight*	Interval Days	Interval Orbits	Longitude Shift°
Cosmos 71°A	8	125	2.3
Cosmos 71°B	2	31	1.2
Cosmos 71°C	6	92	2.1
Cosmos 71°D	1	15	1.5
356	2	31	1.8
165	1	14	−0.9
176	1	14	−0.6
211	1	14	−0.2
233	1	14	−0.9
283	1	14	−1.4
319	1	14	−1.1
380	1	14	−0.7
408	1	14	−0.9
472	1	14	−0.3
601	1	14	−0.2
703	1	14	−0.8

Notes: *All are Cosmos flights (apart from Intercosmos 8 in the Cosmos 71° C group). The mean orbits of the Cosmos 71° flights are as follows (after Ref 1, rounded to 5 km).
A=270-405 km. B=270-485 km. C=205-645 km. D=270-815 km.

4. C. S. Sheldon II, *Soviet Space Programs, 1971-1975, Vol. 1.* US Government Printing Office, 1976, p. 53.
5. Pavel Elsztein, *ibid*, p. 61.
6. C. S. Sheldon II, *ibid*, pp. 109-111.
7. Phillip S. Clark, "The Skean Programme," *Spaceflight*, 20, p. 300 (1978).
8. Phillip S. Clark, *ibid*, pp. 303-304.

BRITISH ALLOYS IN US SPACE PROGRAMME

Britain is helping maintain America's space programme with the supply of special alloys and aerospace products. In particular, the resources of the British Aluminium Group, which extend to magnesium products as well as aluminium, make it possible for Britain to play a significant role in the construction of Earth satellites.

Hardware and vehicles for many satellites produced by the Space Systems Division of the Lockheed Missile and Space Company at their Sunnyvale, California, plant, require special alloys and products, particularly aluminium and magnesium alloys, and at short notice.

Supplies of these materials are becoming difficult to obtain in North America. In particular, the design of fuel tanks is based on welded 2021 alloy, which contains 6 per cent copper with minor additions of tin, vanadium and cadmium. This alloy is no longer available in the US and is produced by The British Aluminium Company in the form of forging billet, sheet, thin plate, and extrusions. British Aluminium also supply rolling block for the production of thick plate.

The advantage of alloy 2021 is in the improved strength levels obtainable after welding, compared to 2219 because, to achieve full properties, cold work by stretching is not required.

The supply of these materials by Britain has allowed continuation of the existing design and has saved the considerable expense and time of requalifying the designs in 2219 with attendant weight penalties.

MANNED SPACE EXPLORATION: THE WAY TO THE FUTURE

Over the past three years the Soviet Union has established a huge lead in human exposure to space flight during a series of activities aboard the Salyut 6 space station. On 30 September, Lt.-Col. Leonid Popov and flight-engineer Valery Ryumin equalled the 175-day space duration record set by previous occupants of the station, Lt.-Col. Vladimir Lyakhov and Ryumin himself. How do the bio-medical results compare with the findings of US astronauts who spent 84 days in space in 1974? In an APN interview, one of the long-duration cosmonauts Lt.-Col. Lyakhov shares his impressions of work carried out aboard Salyut 6 and discusses future plans. We follow with an exclusive interview which our correspondent Mario Mutschlechner obtained with Dr. Charles A. Berry, physician of the US astronauts, who caught up with him during a conference at the Sheraton Hotel, Mexico City.

The Vladimir Lyakhov interview:

Q.: *Several space endurance records have been set aboard Salyut-6. Your flight with Valery Ryumin lasted for 175 days. What are the specific features of prolonged manned space flights?*
VL.: Man's short stay on board a space vehicle does not meet the requirements of science and technology any more.

Investigations from an orbiting station can be compared with the operation of polar stations in the Antarctic. The exploration of Antarctica, not from permanent bases, but through direct short-term expeditions to the icy continent would hardly be efficient.

The switch-over to prolonged flights is a transfer to a qualitatively new stage of space research. In prolonged flights crewmen so fully adapt themselves to space conditions that the efficiency of the mission increases two or three-fold as compared to short-term flights.

The long work of space crews reduces the number of cargo ships and carrier rockets needed to bring new shifts of cosmonauts to the orbiting station. This enhances the economic effect of research.

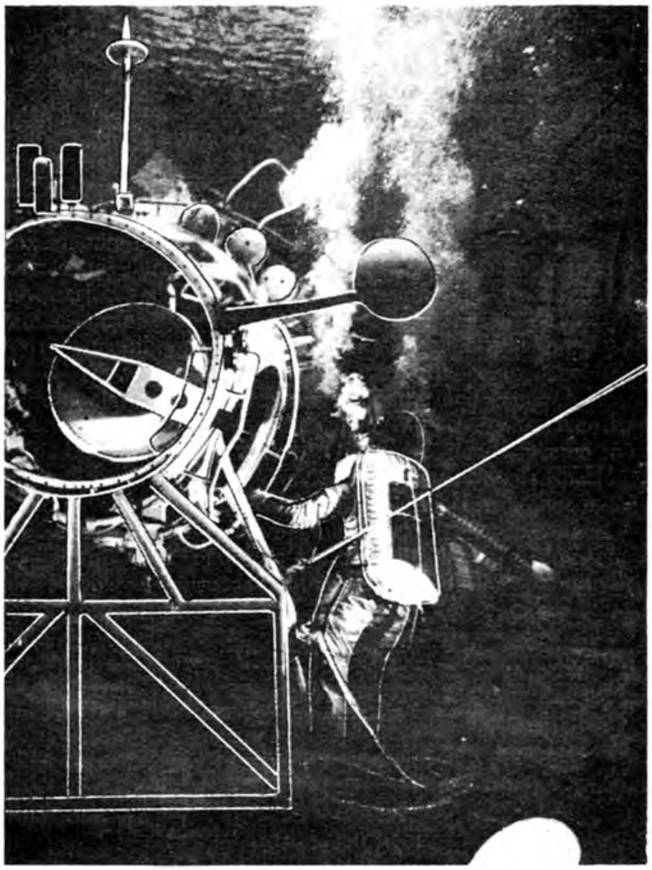
Today's prolonged manned space flights open the way to the space exploration of tomorrow, with missions lasting for many months and the enormous scope of work inside and outside space vehicles. Space research of tomorrow will spell out permanently operating stations in satellite orbit of artificial satellites of the Earth, the Moon, Mars and Jupiter, numerous systems of communications, navigation and collection of meteorological information, space-borne enterprises turning out unique products and giant satellites supplying the Earth with electric power from outer space.

Q.: *Is it difficult to work in outer space for a long time?*
VL.: In short-term space flights one can put up with many things, for instance, with every day discomfort. Who is your neighbour has no special importance either: there is too little time for incompatibility to take its effect. But a prolonged stay in a spacecraft gives rise to lots of problems.

For instance, during the flight one wants to get rid of constant control over numerous systems on board the station, from the strict routine of the day regulating every step of the space pilot. This problem can be solved through the automation of the maximum number of operations in the station. The number of onboard computers should be increased.

At present, the station's compartments are not divided into living modules and work compartments. The living and work compartment is the same, and this is not very convenient.

The future is with stations of a modular type, where the living module, the instrument and research compartments can be launched separately and then docked to each other in outer space. With a change in the research programme, modules will be replaced.



Training for weightlessness in the underwater simulator at the Gagarin Cosmonauts' Training Center. Immersed in the huge tank is an engineering mockup of the Salyut 6 space station.

Novosti Press Agency

Col. Leonid Popov and Valery Ryumin returned on 11 October 1980 after setting a new world's space flight endurance record of 184 days 20 hours 12 minutes. Ryumin's total flight time, in three missions, stands at 361 days 21 hours 14 minutes.

Q.: *You and Ryumin more than any other Salyut 6 crewmen carried out repair and maintenance operations in the station. To what extent are such operations effective in outer space?*
VL.: In fact, repair and maintenance work has been done on a large scale only in Salyut 6. It took our crew a month to carry out this work. We performed 21 operations, and the most complicated and labour-consuming task was the repair of the station's integrated propulsion system, when we had to pump fuel from the tank which became defective.
Q.: *As has been shown by the last flights, repairs must be done not only inside the station, but also outside it. Are these operations difficult and dangerous?*
VL: Extravehicular activity is much more difficult. No matter how perfect the spacesuit may be, it cannot ensure as reliable protection for a spaceman as a ship or a station. Besides, it restricts mobility and all movements in general.

However, we gradually acquire experience in executing these operations too. Three crews performed extravehicular activity at the Salyut 6 station. The initiative was taken by Yuri Romanenko and Georgy Grechko. They inspected the external parts of the docking unit which, it was suspected, could have been damaged during the unsuccessful docking of the Soyuz 25 cargo ship with the station.

Vladimir Kovalyonok and Alexander Ivanchenkov disassembled and partly replaced scientific instrumentation on the outer surface of the station.

Ryumin and I made a space walk in order to release the antenna of the radio telescope from the aft compartment of the station.

Q.: *The difficulties of man's life and work aboard spacecraft are accounted for by the unfavourable effect of weightlessness. Do you think that eventually man will be able to adapt himself to it?*

VL: All specialists are unanimous that zero gravity is the main obstacle on man's road to outer space. During space flights we get accustomed to weightlessness to such an extent that it does not hinder our work. After several months of stay in outer space a space pilot experiences a wonderful lightness of the body; the pleasure that all objects surrounding him are weightless.

Aboard Salyut 6 human working capacity exceeded that on the Earth. This shows the high degree of the adaptation of the human organism to weightlessness.

And yet in the post-flight period the volume of our shins decreased and the calcium content in the bone tissue also fell. Changes in the water-salt metabolism and in the oxygen regimen of the tissues, a slight decrease in the number of erythrocytes and haemoglobin have been detected. Such are typical symptoms of the effect of zero gravity.

There are suspicions that weightlessness affects the processes taking place in the human organism at the cellular level. That is why physicians and biologists cannot state that the mechanism of the effect of zero gravity has fully been studied. Weightlessness may spring a surprise on us in the future.

One can ensure man's more efficient activity in outer space only by artificial gravity, through creating a small model of the Earth in space.

If conditions close to terrestrial ones are reproduced aboard manned space vehicles, there will be no biological limit for man's penetration deep into outer space.

PHYSIOLOGICAL AND PSYCHOLOGICAL PARAMETERS OF LIFE IN SPACE STATIONS

Interview with Charles A. Berry, MD consultant, aerospace medicine – by Mario Mutschlechner

MM: *In your paper this morning you talked a lot about weightlessness. Would you like to fly yourself; would you like to enter weightlessness yourself; have you ever thought about that?*

CB: Oh yes, I thought about it many times as we started years back selecting the original seven guys and I guess that's never left my mind. It surely was never feasible in the flight programmes we've had to date. With the Shuttle, I think it could become feasible. Chris Kraft and I have always said we'd like to fly someday on the Shuttle. I don't know if that will ever come about, but I would love to do it.

Dr. Charles A. Berry. Based at the Manned Spacecraft Center, Houston, Texas, Dr. Berry was responsible for the astronauts' health while in training and during space flights.

NASA

MM: *Looking back and regarding all the experiences you've accumulated during the Apollo Programme: Apart from the complex reactions of the human organism to weightlessness, what were for you the most significant findings in understanding how man functions in extraterrestrial environments. Would you say that he functions out there just as he does on Earth, including psychologically?*

CB: I think man takes his physiology and his psychology with him wherever he goes and that's why man is the unique creature that he is. The interesting thing that we have found and that allows him to function properly in any environment, is the tremendous adaptivity of the human body. Now the word adaptation is probably not correctly used, because that implies that you have adapted genetically, and that is not what we mean here, obviously. I am using the word in the sense of accommodation or acclimatisation, so I'm using the term loosely. I say he adapts, and what has he done? He has adapted his entire physiology to a zero-g environment. And not only did he do that, but then he turned around and in a very short period of time adapted himself to a 1/6th g environment on the lunar surface and learned to operate on that surface, as you saw, in very short periods of time. Not that we didn't do a lot of training for that ahead of time; we even had 1/6th g simulators so he could have the feel of 1/6th g.

MM: *In this process, was there anything surprising for you or something that you did not expect?*

CB: Well, I guess the first thing we saw, and we expected it, were cardiovascular changes. The first thing that we saw in Gemini during extravehicular activity was that the men paid a tremendous price for working in that environment. We had to abort the first four attempts outside after Ed White . . .

MM: *. . . because the men were not trained to do that, they had no underwater training?*

CB: That's right! What happened, they were working against the environment all the time. Every time they made a movement they moved in the opposite direction. They were fighting inside the suits and so they ended up with very high respiratory rates and very high heart rates. So we had a real concern how to cut this down and, as you know, we were able to do it only with the very last Gemini flight, with Buzz Aldrin. We installed supports so he could fix himself at a place and do the job. I guess the next thing we had not thought about at all were the cosmic rays, the light flashes. The next surprise were the arrhythmias that occurred on Apollo 15, and that was a very big concern. At that time that was totally contrary to anything we had seen, even through fourteen days of spaceflight. Here we had two guys who developed an arrhythmia after they had been on the lunar surface and had gotten back in, just as they were getting ready to get into the Command Module; they were getting ready to separate the Lunar Module.

MM: *You know now why this happened?*

CB: Well, in retrospect we looked at the whole mission, because they also took longer to recover than any crew had ever done. And so we went through everything on the mission and we found our food was low in potassium content. As a result of that on the remaining two Apollo missions 16 and 17 we added potassium to the food. The crews didn't like that,

because of the taste, but we had never another arrhythmia occur. Now, we did have a brief episode of arrhythmia in Skylab with one crewman during an exercise regime on the bicycle ergometer. That, and the prolonged recovery period, concerned us because it was like the things the Russians had seen when they had flown eighteen days on one flight and the crew had taken about thirty days to recover. And that was a shock, they never explained that nor have we totally explained it. We think that explains our Apollo 15 episode, we feel comfortable with that. I'm not sure their episodes can't be explained on the basis of the fact that their spacecraft has random movement all the time. And that helps to explain their motion sickness problems too, which they've always had and we never had until Apollo. In fact that completely turned their programme around and I think it totally slowed their programme. I feel the fact of really seeing motion sickness on their very second flight, with Titov, coloured their entire physiologic and medical activity from that point on. Their training activity was aimed at producing men who would not be susceptible to this and it was unsuccessful. Their spacecraft, particularly when they put the solar panels on, randomly rotates all the time, and they don't have the fuel to stop that kind of rotation . . .

MM: *But that's not practical either way since they don't have the solar panels directed towards the Sun.*

CB: That's right! So it's a problem. Now the other thing in relation to surprises or concerns: Each of the extensions of time from 4 days to 8 days and then to 14 days were big decision points. I decided early, after the end of Mercury when we'd gone about 36 hours, and the first Gemini flight was going to be scheduled for 7 days. And I said: "I don't want to do that. I think we ought to go 4 days, because we are taking a big jump from 36 hours to 4 days, but that's about two to four, I'll take that. And I want to double things, 4, and then 8." And we did 14 because we really didn't think the crew could stay over 14 days in the Gemini spacecraft and, furthermore, we were never going to fly a lunar mission longer than that and we were trying to qualify for lunar missions. So prior to the 4 day flight we had people from all over the country calling me the night before launch saying our crew is going to die. When they get out of the spacecraft they would be unable to stand upright, when they would try to get into the raft they would drown. We even had some guys on my own staff who had conned some of the engineers into designing a way to pump water from outside the spacecraft into the suit to try and put pressure on the lower body. We never did that. So there was a lot of worrying and one of the best things was to see these guys walk out on the carrier deck after those 4 days. And then, in Apollo, the second mission, where we went around the Moon was a big decision point for us medically as for the engineers. And then the quarantine operations were difficult, very difficult. That was one of the more difficult times of my life, I guess, in NASA. Next would be Apollo 13, when we had the explosion. We had to try to figure out all the things we were going to do to keep that crew alive and to get them back; we had a lot of problems with that, as you know. Apollo 14 was a problem in flying Al Shepard, whom we had grounded for a long time because of Ménière's disease. I requalified him with a shunt operation and we tested him again and qualified him and it was successful. The same thing happened with Dick Slayton; he was also grounded for a long time. Apollo 16, 17, Skylab were just the battles, everyday things; there were no big problems.

MM: *Let's go a little bit into the future now. Nowadays the Russians seem to be leading in understanding the psychophysiological aspects of spaceflight. Their preflight vestibular training has resulted in an almost immediate vestibular adaptation to zero-g . . .*

CB: I don't agree with that! Who said that?

MM: *I believe this to be the case. Pulse coincidence measurements and adherence to leadership structures have assured the compatibility of the crews and the daily exercise regime; the type and quantity of food as well as the sleep-wake rhythm aboard Salyut 6 have maintained the work efficiency and morale of the crew for six months at a time. What is NASA learning from this and how will this knowledge be applied to Shuttle flights?*

CB: I don't think it will be applied to Shuttle flights at all.

MM: *Because they will be too short?*

CB: That's right! Shuttle flights for years are probably only going to be seven days long. So medically they are not going to give us any of that kind of data that the Russians are getting from long-duration flights. The biggest medical problem for us, as far as the Shuttle is concerned, is the motion sickness problem. Even the calcium problem that we have identified is not a problem for the Shuttle. Hopefully we will get to 30-day missions, but again, that's not really long compared to what we've done already. I think the Russians have built upon our data, and they should do that, and now we need to learn from their data and need to extrapolate those data for missions that we will do. Now, people come from different social backgrounds: Russian cosmonauts are not exactly like US astronauts. There are a lot of similarities, but there are certain things in backgrounds that would not ever be exactly the same. And so we have to put that into our own context here, particularly all the psychological aspects, which they deal with very much. I think the data that they are getting are invaluable, because it's going to allow us to continue to expand. We talked to some of them about the six months data already, and from the first impression it does not look as if we're seeing anything different from what we have seen as far as physiological effects are concerned.

MM: *So that means that osteoporosis is not levelling off, it continues?*

CB: Well, we have not seen any evidence, that osteoporosis is levelling off; we are still loosing the calcium. . . .

MM: *What do you mean by "we"? NASA, 84 days? What about 175 days? What do the Russians know about this?*

CB: Now, it appears, and this is "first looks," they didn't want to get into the details because they hadn't analyzed all of their stuff yet, and that's understandable. It appears there is still a calcium decrease going on. So we don't think it's a problem in missions of about a year. To my knowledge they have not used any supplements either; they haven't used calcium supplements and I think that's positive. Somebody might say: "Why don't you take care of the crew; they're losing the calcium, why don't you give it to them?" You don't really need to do that, from my point of view, yet. If we talk about very long missions, those are the ones for which we'll have to have a fix. We got fixes for everything else; that's the one we don't have a good fix for yet and we need to develop that. I think it's important we do so. I feel very good about what the Russians are doing. I think they are collecting very interesting data which should be a real help to us for long duration flights as we look ahead at planning Mars missions, which I hope we'll be able to do some time. I firmly believe we are going to have factories and that sort of thing continuing in Earth orbit. So the more data we get for longer periods the better off we are. And we need to apply that data.

MM: *Another problem area is depression on long duration flights. What can be done to counteract it? The work load, physical exercise, family ties, videophones. . . .?*

CB: I think the Russians have worked very hard on that. There are several reasons for the visits they're having. A number of years ago we went over the Arctic data in great detail, because it was the most applicable data to this kind of isolation. They have only two people in the Salyut and they're there for very long periods of time. You know, the one guy who is up there right now (Valery Ryumin) was there for six months previously. It's unbelievable that they got him to go back! And so, they've put these visits in; they have a lot of passage of news back and forth. On Skylab, we set up com-

munications with the families that were private, and I think that's important to do! You can't have everything that you're saying totally come out on an open wire to the world press. And so I think they ought to have the capability to talk to their families. So contact with the Earth and the things that are going on there is an important thing to do and it helps to change that feeling (of isolation). Of course, visits have been very helpful to them; and then we found in our own activities - and I think every crewman you'd talk to would say this is certainly the case - that the workloads they were given were both a curse and a tremendous help. They had something to do all the time and they were always worrying about the time schedule. It was something that totally occupied their time and therefore they never felt any sort of pressures from this at all. Now I think it's very normal to have some depression about being continually in the same situation, and you have to do everything possible to vary that. And I think we ought to use some very ingenious ways to do that, and that can be television communication back and forth. You ought to develop things where the crew can see things that are going on back on Earth and, obviously, if you can visit, that will happen more and more as they get larger space stations. They've been able to do that very well!

MM: *You said before US crews never felt any pressure from the work load. That doesn't seem to be true. The third Skylab crew, for example . . .*

CB: Oh no, I said they did feel pressure from the schedule, from the workload. I wanted to say we never had a crewman who felt depressed as a result of that, because of these workloads. In fact, with one Skylab crew we had a lot of arguments back and forth about what we were going to do.

MM: *And this happened, obviously, because you overscheduled the third crew. Apparently the Russians are doing this currently in a better way. They're doing this step by step and they wait for the reaction from the crew.*

CB: With Skylab we had a daily morning conference where we planned all the things that were going to be fitted into the day based on what had happened to the hardware and all the rest of things during the last 24 hours. Now, that's important to do and one has to change things on a 24 hour basis, maybe even shorter than that. But one of the big problems we faced was that we had three big areas that we were trying to cover scientifically. And behind each of those areas you had a whole group of scientists. We had a lot of Earth observation activity; we had a lot of Sun observation and a lot of medical activity and these were always behind for time and that gets to be a real problem with the crew. And then, as your missions get longer, which was the case with the third crew, we've got a long time already on that spacecraft, on our workshop, and we're beginning to get things that fail and that you'll have to fix. We also had a lot to do on the first mission, as you remember, because nothing worked. The second crew was really the only one that enjoyed any sort of activity where they didn't have to fix a whole lot of things. The first and the third crew had to do a lot of that and that put a lot of pressure on them.

MM: *Now a question in relation to the Orbital Workshop, you mentioned it before. The two main parts of the Skylab were the Orbital Workshop and the Multiple Docking Adapter, which represented different types of architecture. The MDA was an architecture of weightlessness, a radial type of architecture, whereas the OWS simulated floor and ceiling. Some of the astronauts, like Ed Gibson and Joe Kerwin, grew accustomed to the difficulty of orientation within the MDA, whereas other crewmen were against this lay-out without up or down. Now what do you think will be used in future space stations, the zero-g architecture of the MDA or a simulation of terrestrial architecture like in the OWS?*

CB: We've thought a lot about these design features. You named two people, but I could name more on the other side who would say: 'I don't like it that way. . . ."

MM: *Exactly, that's why I'm asking. . . .*

CB: That's part of our difficulty. I think generally you could get all of our crews to agree that they have been able to handle weightlessness from the physiological viewpoint and from the orientation and operating viewpoint. It has become a help to them rather than a hindrance. Therefore they're not pushing for having gravity put in, OK? Now that being the case I think it's going to be a mixture. I would bet that from an architectural viewpoint we are going to have combinations of the orbital kind of thing versus the ground based kind of thing. I don't think we can totally do away with ground orientation. Eventually we may have something like that, but I think even when we get to a space colony type of thing you'll have ground orientation, I don't think you'll be able to get away from it!

MM: *In this context, do you know anything specific about the Russian space station that is planned to be launched in 1985, for 12 people, I just read about this.*

CB: I just read about it too so I don't know anything more than you do. We both must have read the same story. All I do know, and I'm not playing games with you, is that's perfectly consistent with what the Soviets are trying to do. They have had almost a constant presence in space for the past year while we had nothing up there. They are going for the long-duration activity. A lot of people say they haven't been to the Moon yet. What they're doing is very well planned, they are going to have a capability to have people up there for long periods of time. Their ground-based programme has been heading that way and their flight programme too. And there is no doubt in my mind they'll do it. I think they'll launch the station, certainly by 85; they might even do it before that.

MM: *I know of no other plans in the US Space Programme for a new space station, do you?*

CB: I think one of the crying shames in the world today is the fact that there are no other manned programmes on the book (besides the Shuttle-Spacelab programmes) as far as the US is concerned. And that is truly deplorable because of the long lead time we face! If you were to say today: we're going to do another programme you're talking about years from now before it's done. So that's very bad!

MM: *But you still have interconnections between the Soviet Union and the US in relation to scientific information, I suppose?*

CB: Yes, the groups are still meeting. The current Afghanistan problem poses some difficulties and I don't know what's going to be the result. At the moment that has not affected the Space Medicine Biology Exchange.

MM: *Another question on long term life in space: Given an adequate amount of physical exercise on board, do you believe that people could be living for years in zero-g or do you think that gravity - or simulated gravity - is an absolute must for human survival in space?*

CB: No, I don't think that simulated gravity is an absolute must. In fact, you pay some price for that. Not only do you pay a cost price and a weight price, obviously, but you also pay some physiological price. The minute you put artificial gravity in, you have then to adapt yourself to changing gravity conditions, depending on where you walk on the arm and the angle at which you're walking. So if you move your head in that environment you're asking for coriolis reactions and things. We've proven all that in slow rotating rooms. So you do have a problem if you put gravity in.

MM: *Lieutenant General Vladimir Shatalov believes that sending men into deep space without female company is a sort of breach of human rights. Why do you think the Soviet Union has still no women in cosmonaut training?*

CB: I would suspect that they will fly women. It's like the scientist thing that we went through in Apollo; were we going to fly a scientist or not? They are selecting some more women now (at NASA), the second batch they've just selected. And I don't know why, knowing Vladimir. I know his statement, I know his feelings and I think we'll see mixed crews; there's no question about that! They'll probably surprise us by bring-

ing in somebody from another country. They'll bring a French girl and suddenly fly her. That wouldn't surprise me a bit.

MM: *What will be the main fields of zero-g medical research in the Eighties? Maybe evolution of animals in weightlessness, diseases in weightlessness? What will be done in Spacelab? What would you like to be done? What has been done aboard Salyut 6?*

CB: Well, in Salyut 6 they're just continuing the basic studies looking at the systems where we see change in the body. And that needs to be done! I think we need to do some planning for the future, even in something like the Shuttle. Certainly we could use 30 day flights, but some of the experiments we could do even in 7 day flights, because one just needs the zero-g environment to do that. We need to look at such things as basic cells and basic cell effects. And we need to do some things about surgery, and we need to actually look at wound healing; we need to look at fractures and that sort of thing and what happens in this weightless environment. And we need to do some invasive things that we can't do on man. One can do such experiments on animals, and one can do them with surgery. And I think that's the sort of thing that we ought to do to get as much information as possible for planning ahead. Now, I also think that, while we say you're not going to do a lot in the Life Sciences in 7 day missions, one of the biggest mysteries we have at the moment in our programme is: What happens in that first seven days? That's a very difficult time period to get information on, because operationally we've been very limited as far as sample collection is concerned. For instance, in Skylab we came up in the Command Module and then you're transferring to the laboratory and you've a difficult time getting for example that urine during the first 24 hours. We have not been able to do that, properly, yet. So, because of this, we need to really pin down as detailed as possible the entire mechanism of what this adaptive process is. Because if we could do something to hasten that adaptive process, that would be of great help and I think we need to find that out. So, it would be very helpful if we could identify that, and then it would help the Shuttle, because if you're talking about seven days, we cannot have people getting motion sickness.

MM: *Before I talked about an almost inmediate adaptation of the Russians to weightlessness and you objected to that. Obviously it is not so in the physiological sense but maybe it is so concerning orientation in zero g. And that's quite important. Space motion sickness has been eliminated in some of these people. They have done so much underwater training and T-38 flying and what else, that once they enter weightlessness they more or less immediately feel at ease there.*

CB: T-38? Are you talking about our people?

MM: *I am sorry! I mean the Russians. They must have something similar to that.*

CB: Well, we don't really know. The people that looked to be the least susceptible in Skylab turned out to be the most susceptible.

MM: *Bill Pogue?*

CB: Bill Pogue, okay! We don't know anything more about that right now that tells us anything different about predicting. And the Russians aren't any better at it, amazingly. They don't have any better answer. They have had a belief for a long time. Their vestibular people have believed that it's due to the bloodflow, that this increased bloodflow to the head has caused this vestibular problem. We've done a lot of studies in this area too and I don't believe this. I think they are coming away from that feeling too. It's an otolith problem, it's the otolith becoming weightless, and it's how that reacts with the central nervous system. You get to the point where you block that, and that happens, because you totally adapt within that first week. By the end of the first week you can do anything to them and the vestibular system will not respond at all. So it's just as if you went in surgically and snipped the nerve with a knife. The Russians many years ago started using all kinds of devices, and I've seen all the things they use, like they got swings in their crew training quarters and they put these guys on these swings and all this sort of stuff. Now, that has not been helpful. They still had people with motion sickness. So they haven't done away with it either and it's one of those things that we're handling with medication at the moment. And I think it's vital you do that, but we've got to have a better answer than medication. We've got to find an answer! Is there something in training that we can do? There is not a good training answer right now. I think there is some help in some people. I think it's helpful to do these various things, certainly the underwater things are very helpful, but it's not necessarily prophylactic in everybody.

MM: *So you have no way to screen future astronauts for motion sickness?*

CB: No, and what worries me about that is this: The people we've been flying so far were people who have done a lot of flying. Now you are going to fly a lot of people who haven't done flying in aircraft. We are going to fly people who don't fly at all. And when you do that you increase the incidence of motion sickness, no question in my mind! You're going to see more of this instead of less. And therefore that's a problem we must solve; we've got to come down to the basic mechanism and find out what that is.

MM: *For example, Ed Gibson did a lot of T-38 flying and improved his ability to adapt to zero g.*

CB: Well, Ed thinks that and he honestly believes it. He also did a lot of things underwater and he feels that that helped him greatly in doing his adaptation. Now, that may be true for Ed Gibson, at least if you look at what happened to Ed Gibson. I don't know.

MM: *Just one last question in relation to something you mentioned today and that is: hospitals in weightlessness, in Earth orbit. If you speculate about this, what would you say should be done up there? What kind of people would be treated there?*

CB: Several years ago we started thinking was there some particular benefit that you could get from the weightless environment? Are there more hazards to it than benefits? Certainly, we need to totally understand everything that happens about this adaptive mechanism. If we were going to launch a patient to space we must first totally understand what we're doing to that patient's physiology.

MM: *Thank you very much, Dr. Berry!*

SOVIET/US MONKEY FLIGHT

Launch is set for mid-1981 for the next Soviet-American cooperative biosatellite flight. Objective of the project, designated "Cosmos 81", is to continuously monitor the blood pressure and flow rate of a rhesus monkey during weightlessness. The special instrument for the experiment, called a combined pressure/flow probe (CPF), will be surgically implanted into the left carotid artery before launch. The so-called pressure cuff will provide continuous cardiovascular pressure monitoring by a "Konigsberg pressure transducer" and flow rate monitoring with a "doppler flow transducer". A signal conditioner provided by the Americans will prepare the data for telemetering. Integration of US hardware into the Soviet spacecraft is currently scheduled for May 1981.

The US Principal Investigator is Dr. Harold Sandler, and the manager of "Cosmos 81" for NASA is Kenneth Souza. The work is being conducted at the Cardiovascular Research Laboratory, Ames Research Center, Mountain View, California.

From: "Cosmos 81: US/USSR Cardiovascular Study — Experiment Implementation Plan", February 1980, NASA TM-81178 (NASA microfiche N80-18710).

SPACE REPORT

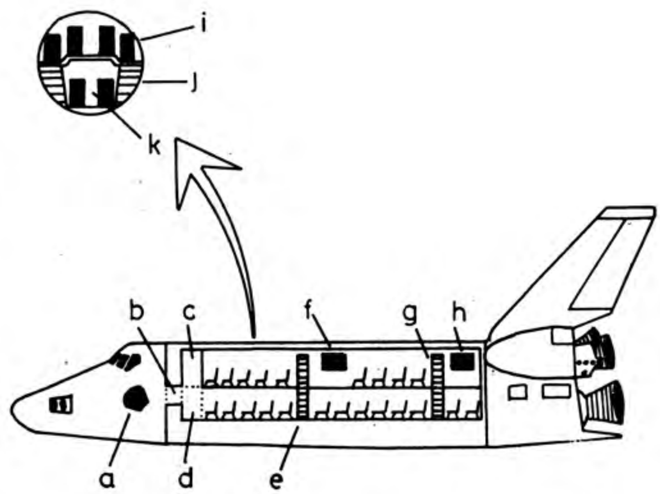
LITTER BUGS IN SPACE

The absence of a Progress ferry flight in the period between the recovery of Soyuz 36 and the launch of Soyuz 38, whether intentional or otherwise, left the Salyut 6 long-stay crew of Leonid Popov and Valery Ryumin with the awkward problem of what to do with two months' accumulation of rubbish and waste, writes Robert D. Christy.

Normally, Salyut's crew would load the offending items into the returning Progress orbital module for it to be incinerated in the upper atmosphere during re-entry. The absence of a convenient refuse disposal vehicle meant that other means had to be used to rid the station of its unwanted cargo. Salyut is equipped with small airlock chambers specifically for this purpose and the crew put these to good use.

Over a four week period starting in the middle of August, more than a dozen extra objects appeared in Salyut's orbit as a result of the dumping operation. Most of the work was completed before the manoeuvre at the beginning of September which preceded the Soyuz 38 launch. This meant that the station had no unwanted orbiting companions during the rendezvous operation; a collision could have left either crew in a rather sticky situation!

This type of dumping operation has been a normal part of Salyut's operation and has resulted in the total number of catalogued objects associated with it rising to nearly eighty. On top of these are several others which have been observed visually but obviously have not responded to radar tracking as they never received catalogue numbers. The August event though was the largest individual operation.



SPACE SHUTTLE ORBITER WITH PASSENGER MODULE:
a. Hatch to crew compartment; b. Tunnel adapter;
c. Extendable docking module; d. Airlock;
e. Forward exit ladder; f. Forward payload bay exit;
g. Aft exit ladder; h. Aft payload bay exit (cross-section of passenger module); i. Upper passenger deck (4 seats wide); j. Storage space;
k. Lower passenger deck (2 seats wide).
Drawing based on Rockwell International artwork.

74-SEAT SPACE SHUTTLE

Rockwell International, prime contractor for the US Space Shuttle, have recently designed a passenger transport module, capable of transporting up to 74 passengers to Earth orbit, writes Keith T. Wilson. This would be placed in the 18 m long payload bay of the Shuttle Orbiter. This ambitious plan is only part of Rockwell's continuing investigation to modify the present Space Shuttle system enabling it to orbit larger and heavier payloads.

The passenger transport module, a large version of a pressurised Spacelab module, would be capable of seating 68 people with additional space for 6 more in the lower flight deck of the Orbiter. The module would be inserted into the Orbiter's payload bay in the Orbiter Processing Facility, in much the same way as Spacelab is inserted. The passenger compartment would have two decks. The upper deck would be four seats wide, leaving room for a 64 cm wide aisle running the length of the module; also on this level would be doors for entry and unloading. The lower deck, only two seats wide with a similar aisle as the upper deck, would have space for storage along both sides of the module. Upper and lower decks would be linked by two ladders adjacent to the payload bay exit doors in the side of the compartment and a tunnel adapter and airlock would link the module with the Orbiter crew compartment. Additional toilet facilities would be included.

Rockwell planners feel that a one or two day flight would be possible with minimum launch and re-entry g-forces on passengers. No sleeping accommodation would be required for such a short flight; the passengers would simply sleep in their seats which would not be too uncomfortable in zero-gravity.

If a passenger transport module was to be carried aboard a Space Shuttle a number of modifications to the Orbiter would be needed. These would include alterations to the wings, life support systems and environmental control systems and the estimated cost of these modifications would be in the region of $220 million.

At present no requirement exists for passenger transport to Earth orbit and it is unlikely that NASA would use the Space Shuttle for ferrying tourists for a two-day sight-seeing trip in orbit. However space passenger transport might well be needed to ferry construction crews to larger space stations or solar power satellites if such space structures are to be built.

Whatever happens this ingenious Rockwell plan brings us one step nearer the time when the commercial spaceplane will become a reality.

SCANNING THE MARBLED CLOUDS

Those pictures of swirling, marbled clouds – so familiar to viewers of TV weather reports – may help meteorologists improve the accuracy of weather forecasts now that the newest US weather satellite has taken up station in geo-stationary orbit at 135°W.

The latest geostationary operational environmental satellite, GOES-D, nearly 12 ft (3.6 m) high and more than 7 ft (2.1 m) in diameter, was built by Hughes Aircraft Company for the National Aeronautics and Space Administration under a $39.4-million contract. Three are on order. GOES-E is scheduled for launch in early 1981; GOES-F will be maintained on the ground as a spare.

NASA procures the spacecraft – which have a design lifetime of 7 years – for the National Oceanic and Atmospheric Administration, which operates them in orbit.

GOES-D was launched by a three-stage Delta 3914 from Cape Canaveral, Florida on 9 September 1980. Like its predecessor, the satellite orbits synchronously at 22,300 miles (35,600 km) over the equator to gather and transmit information on weather conditions over Canada, the United States, Central and South America, and a large area of the Atlantic Ocean, warning of impending storms by providing a new satellite "picture" every half-hour, day and night.

The GOES satellites are part of the world weather watch project, which includes Japan's GMS and Europe's Meteosat.

The primary instrument payload of the GOES-D-E-F series is a visible and infrared spin-scan radiometer (VISSR) atmospheric sounder, called VAS, designed and built by the Hughes Santa Barbara Research Center to provide new data on the vertical structures of temperature and moisture in the atmosphere.

"The development of severe weather is characterized by vertical development of clouds," said E. Larry Heacock, director of the office of systems integration for the national environmental satellite service, a NOAA unit. "Our monitoring of severe storms is currently limited to observing the development of tops of clouds as they build altitudes. If there is what we call an 'undercast' we can't do soundings beneath the top cloud layer."

However, he said, if the VAS experiment is successful, it will greatly enhance the ability of meteorologists to determine the intensity of storms and to track them as they build.

The information collected by VAS is being processed and transmitted to a receiving station at Wallops Island, Virginia, where it passes through further interpretative steps before being beamed back to the satellite and then relayed to various users in the United States.

The GOES satellites also carry data collection systems to receive and relay information sensed by surface platforms, where instruments gather data from river, rain and tide gauges, seismometers, automatic weather stations and buoys. The platforms transmit data at regular intervals, or when interrogated by the satellites. When certain platform instruments sense changes beyond predicted parameters, an emergency alarm transmits data as it occurs.

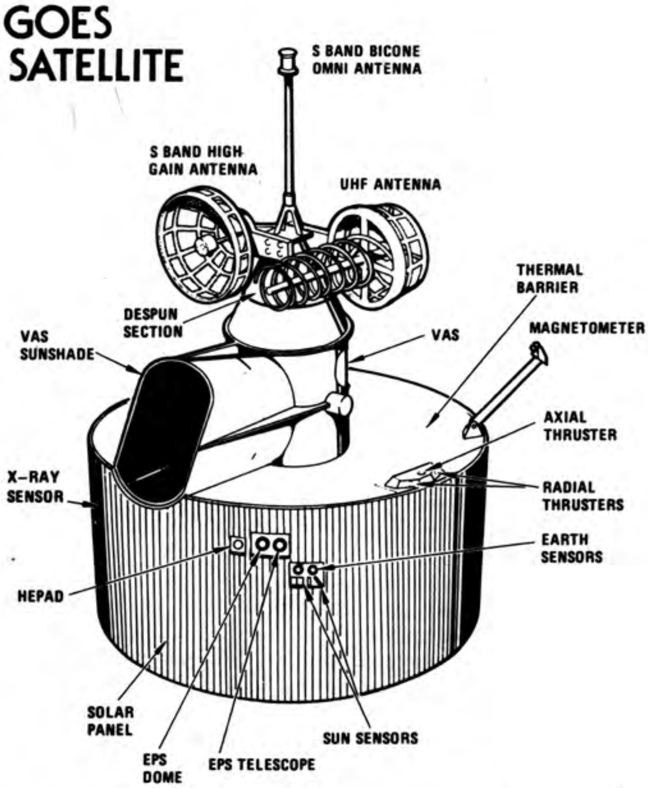
The satellites also carry a space environment monitor, called SEM, which consists of instruments that detect solar protons and electrons, alpha particles, X-rays and magnetic fields. This information is useful, for example, in managing telecommunications and electrical power distributions.

The GOES spacecraft body, which carries VAS and other instruments, spins at 100 rpm, while the antennae are de-spun so that they point constantly at the Earth. The spacecraft uses this spinning motion to take its photographs. A scan mirror in the instrument's camera steps a small angular step each revolution. It requires approximately 1,800 steps or line scans to make a full image of the Earth that the GOES satellite covers. Full Earth images can be scanned in approximately 18 minutes, which enables meteorologists to monitor weather systems as they build and move across the areas under view.

In addition to their various roles in providing frequent weather pictures, the GOES satellites also:

- Help save lives during hurricanes, tornadoes and severe storms by providing scientists with advance warning.
- Help government and private industry to manage fishing, agriculture and water distribution.
- Help to prolong by at least a month the shipping in the Great Lakes by charting ice-free open waterways.

During the spectacular Mount St. Helen's eruption, a GOES satellite provided "pictures" every half-hour as it tracked the drift of volcanic ash from west to east across the United States.



GOES-D (Geostationary Operational Environmental Satellite): principal features.

Hughes Aircraft Company

SOUTH ATLANTIC FLASH

A US Defense Intelligence Agency report has concluded that a mysterious flash over the South Atlantic in September of 1979 was probably caused by a clandestine nuclear explosion, writes Gerald L. Borrowman.

The report, said to be hedged with uncertainties, disagrees with the opinion of a White House-sponsored panel of non-governmental experts who leaned to the view that the flash stemmed from natural causes.

The issue arose on 22 September 1979, when a VELA nuclear test detection satellite registered what was described as an "optical flash". In the nearly 10 months since, officials said, no tangible evidence, such as fallout traces had been detected or registered.

The conclusions of the report were based principally on readings from VELA satellite instruments.

In April of 1980, a panel of senior defence scientists said experts had studied between 20 and 30 different kinds of sensors without producing any evidence of nuclear explosion except the flash.

The present VELA satellite system, which first went into orbit in 1963, is aimed mainly at the Northern Hemisphere because that is where the Soviet Union and China conduct tests.

The NAVSTAR 6 satellite launched on 26 April 1980 is the first Global Positioning System (GPS) navigation spacecraft to carry a sensor package to detect and locate above-ground nuclear explosions. The Department of Defence plans to install these sensors on future NAVSTAR satellites as part of the Integrated Operational Nuclear Detection System (IONDS). The system is designed to provide military command authorities with information to evaluate damage from a nuclear attack.

SOVIET MAGNETOSPHERE SATELLITE

A Soviet spacecraft planned for launch in 1979 for the International Magnetospheric Study (IMS) containing three French experiments, had not been launched by the middle of 1980. A similar fate befell the promised Soviet geosynchronous metsat recently.

According to the French, the satellite called ARCAD 3 (Arctic Auroral Density), one tonne mass, is intended for a polar orbit of 400×1,500 km. A French computer being carried for the first time on a Soviet spacecraft will permit direct data transmission to France.

SOCIETY NEWS

SPACE TRANSPORTATION SYMPOSIUM

This one day meeting was organized by the Space Technology Committee of the British Interplanetary Society in the new headquarters building on 11 June 1980 following concern for the lack of a European policy on Space Transportation beyond Shuttle and Ariane. It is clear that the next phase of space development lies in the establishment of large structures in geostationary orbit and that of the realization of transportation beyond geostations, will critically depend on the way we succeed in this first phase.

A most successful day saw spirited discussions covering these issues:

- *A European programme to participate with the USA in the provision of the transportation system (GEO) required to establish large structures in geostationary orbit from shuttle launch.*
- *A European transportation system, based on Ariane for LEO (Low Earth Orbit) and GEO (Geostationary Earth Orbit).*
- *European man-in-orbit prospects.*

The major part of the discussion was on the first of these issues stimulated by the papers of V. A. Caliori (Boeing) and D. Stott (BAeDC) on various Tug concepts for GEO.

Large structures will be required for the composite telecommunications and earth resources stations (TAERS) and the Solar Power Stations (SPS). Ivor Franklin in his paper reminded the audience that although the total costs of the Solar Power Stations, associated transportation system (GEO) and ground power receiving platform is very large it is comparable with the UK investment in North Sea oil for the same energy return. - P. J. Conchie.

BIS LECTURE ON 10TH PLANET

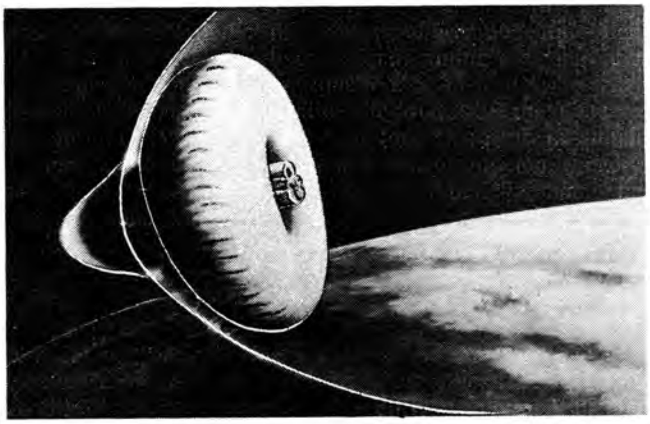
Vice-President Tony Lawton assisted by Penny Wright gave a fascinating lecture on 8 September to the West of London Astronomical Society at Ruislip, Middlesex, on the possible evidence for there being at least one more major planet in the Solar System. Without going too deeply into mathematics the lecture covered the finding of Uranus and the planet-hunting that tracked down Neptune and Pluto. The conflicting roles and the strengths and weaknesses of the leading characters and supporting players of what is still an unfolding story were also highlighted.

The lecture showed that Pluto was now known to be so small and "light-weight" that it could not possibly be responsible for the perturbations reported for both Uranus and Neptune. Either these were purely coincidental and Pluto's finding was an accident, or they were real, and the planet responsible was yet to be discovered with Pluto being found where it was simply because it was in the right niche.

A possible search area for Planet X was then outlined but the task of searching for such an object was stressed as being difficult and laborious demanding a great deal of care and patience.

Led by their President (Professor Alec Bohsenberg) the questions from the audience flew thick and fast and ranged from apparatus required to do the search to how far the gravitational field of the Sun extended. Hopefully, they were all properly answered.

Afterwards, over coffee, some members of the audience expressed surprise that the British Interplanetary Society was so deeply interested in planetary dynamic and positional astronomy. "We thought that you chaps were mostly interested in rockets and how to get to the planets," was one comment. Mr. Lawton's reply was that the BIS was interested in *all* aspects of planetary work and covered the whole range of planetary to galactic astronomy as well as rocketry!



One of the novel concepts discussed at the Society's Space Transportation Symposium last summer: the Orbital Transfer Vehicle being retarded during atmospheric re-entry by a "Ballute".

Boeing Aerospace

Thanks are due to Robin Seadgell, Chairman of the West of London Astronomical Society, for helping to arrange what was undoubtedly an interesting evening for both audience and lecturers.

"FIRST NIGHT"

The informal evening "First Night" put on by the Society in the new Headquarters Building on 7 October turned out to be a huge success. Greeted by the President Mr. Gordon V. E. Thompson, Vice-President, Mr. Anthony T. Lawton, and Executive Secretary, Mr. L. J. Carter, new members were acquainted with the History and Activities of the Society since its foundation in 1933 and made a guided tour of the Building. Great interest was taken in the Society's many technical contributions over the years enshrined in paintings by the late R. A. Smith many of which are now reproduced in the Society's new publication "High Road to the Moon". The imposing portrait of Sir William Congreve, the 19th century British rocket pioneer, which now graces the reception room, also aroused much interest.

Members of Council and standing committees attending this meeting say they were greatly impressed by the enthusiasm and constructive comments expressed by members, many of whom had only joined the Society in recent months. There was great appreciation of the Society's efforts in creating such a fine Headquarters Building and maintaining the "ship" on course despite the ravages of inflation.

Society officials in turn praised the total B.I.S. membership for continuing to support the drive for new members, which is one clear way of mitigating the effects of inflation. If every existing member introduced a new member we should be entering much calmer waters.

BORIS PETROV — Obituary

Academician Boris Petrov, Vice-President of the USSR Academy of Sciences, chairman of the Intercosmos Council and a good friend of our Society, died recently at the age of 67.

Boris Petrov was buried at the Novodevichye Cemetry in Moscow. An obituary signed by Leonid Brezhnev, Alexei Kosygin and other leaders spoke of him as "a prominent scientist in the field of automatic control systems, a talented organiser of space science and of international cooperation in this sphere, a prominent public figure and a wonderful person who devoted his life to his country . . ."

KENNETH W. GATLAND

SATELLITE DIGEST - 142

A monthly listing of all known artificial satellites and spacecraft, compiled by Robert D. Christy. A detailed description of the information presented can be found in the January 1979 issue, p. 41.

Continued from November-December issue]

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (Kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclination (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Cosmos 1200	1980 Jul 9.53	Cylinder+sphere	6 long?	202	302	72.81	89.58	Plesetsk
1980-59A	14 days (R)	+cylinder-cone?	2.4 dia?	226	289	72.86	89.70	A-2
11884	1980 Jul 23	6000?		225	340	72.86	90.20	USSR/USSR (1)
Ekran 5	1980 Jul 14.94	Cylinder+2 panels	5 long?					Tyuratam
1980-60A	indefinite	+antenna array	2 dia?		geostationary orbit			D-1-E
11890		2000?						USSR/USSR (2)
Cosmos 1201	1980 Jul 15.31	Cylinder+sphere	6 long?					Plesetsk
1980-61A	13 days (R)	+cylinder-cone?	2.4 dia?	211	246	82.33	89.12	A-2
11894	1980 Jul 28	6000?						USSR/USSR
Rohini	1980 Jul 18.11	Spheroid	0.5 dia					Sriharikota
1980-62A	3 years	40		306	919	44.75	96.85	SLV-3
11899								India/India (3)
Molniya 3 (13)	1980 Jul 18.44	Cylinder-cone+6	4.2 long?	457	40817	62.79	736.48	Plesetsk
1980-63A	12 years	panels+2 antennae	1.6 dia?	452	39905	62.83	717.82	A-2-e
11896		1500?						USSR/USSR (4)
Soyuz 37	1980 Jul 23.773	Sphere+cone-	7.5 long	190	273	51.58	89.07	Tyuratam
1980-64A		cylinder	2.2 dia	258	294	51.49	89.97	A-2
11905		6500?		336	351	51.62	91.35	USSR/USSR (5)
Cosmos 1202	1980 Jul 24.53	Cylinder+sphere	6 long?	197	306	72.85	89.58	Plesetsk
1980-65A	14 days (R)	+cylinder-cone	2.4 dia?	226	289	72.83	89.70	A-2
11907	1980 Aug 7	6000?						USSR/USSR (6)
Cosmos 1203	1980 Jul 31.32	Cylinder+sphere	6 long?	212	268	82.32	89.35	Plesetsk
1980-66A	14 days (R)	+cylinder-cone?	2.4 dia?	259	273	82.32	89.87	A-2
11915	1980 Aug 14	6000?						USSR/USSR (7)
Cosmos 1204	1980 Jul 31.43	Octagonal ellipsoid?	2 long?					Kapustin Yar
1980-67A	1 year	550?	1.5 dia?	345	538	50.66	93.34	C-1
11917								USSR/USSR
Cosmos 1205	1980 Aug 12.49	Cylinder+sphere	6 long?	198	305	72.82	89.57	Plesetsk
1980-68A	14 days (R)	+cylinder-cone?	2.4 dia?	225	293	72.82	89.73	A-2
11924	1980 Aug 26	6000?						USSR/USSR (8)
Cosmos 1206	1980 Aug 15.23	Cylinder+2 panels?	5 long?					Plesetsk
1980-69A	60 years	2500?	1.5 dia?	629	631	81.20	97.37	A-2
11932								USSR/USSR (9)
Cosmos 1207	1980 Aug 22.42	Cylinder+sphere	6 long?	209	255	82.32	89.20	Plesetsk
1980-70A	13 days (R)	+cylinder-cone?	2.4 dia?	217	228	82.32	89.00	A-2
11938	1980 Sep 4	6000?						USSR/USSR (10)
Cosmos 1208	1980 Aug 26.65	Cylinder+sphere	6 long?					Plesetsk
1980-71A		+cylinder-cone?	2.4 dia?	171	336	67.14	89.60	A-2
11945		6000?						USSR/USSR (11)
Cosmos 1209	1980 Sep 3.43	Cylinder+sphere	6 long?	209	279	82.35	89.43	Plesetsk
1980-72A	14 days (R)	+cylinder-cone?	2.4 dia?	259	272	82.34	89.87	A-2
11950	1980 Sep 17	6000?						USSR/USSR (12)
Meteor 2 (6)	1980 Sep 9.46	Cylinder+2 panels	5 long?					Plesetsk
1980-73A	500 years	+2 antennae	1.5 dia?	846	892	81.25	102.40	A-1
11962		2500?						USSR/USSR (13)

Supplementary notes:

(1) Orbital data are at 1980 Jul 9.7, 10.3 and 21.2.
(2) USSR domestic TV relay satellite serving remote communities, located above 99° east longitude.
(3) First Indian built and launched small satellite.
(4) Orbital data are at 1980 Jul 18.5 and Aug 16.5.
(5) Manned ferry vehicle carrying an Intercosmos crew of Viktor Gorbatko and Pham Tuan (Viet-Nam). Soyuz 37 docked with Salyut 6 at 1980 Jul 24.835 and the crew returned to Earth in Soyuz 36 after a flight of 7.864 days. Orbital data are at 1980 Jul 23.8, 24.0 and 25.3.
(6) Orbital data are at 1980 Jul 24.6 and 25.4.
(7) Orbital data are at 1980 Jul 31.4 and Aug 1.7.
(8) Orbital data are at 1980 Aug 12.8 and 13.2.
(9) Possibly an electronic reconnaissance satellite.
(10) Orbital data are at 1980 Aug 22.7 and 30.0.
(11) Long life photo-reconnaissance satellite.
(12) Orbital data are at 1980 Sep 3.5 and 4.5.
(13) USSR meteorological satellite returning cloud cover photographs and other data.

Amendments:

1979-1A, Cosmos 1070 was recovered 1979 Jan 20, lifetime 9 days.
1979-8A, Cosmos 1074 description is Sphere+cone-cylinder, 6500 kg?, 7.5 long, 2.2 dia.
1979-10A, Cosmos 1075 perigee should read 472 km.
1979-22A, Progress 5 re-entered 1979 Apr 4.98, lifetime 23.74 days.
1979-24A, Cosmos 1081 perigee is 1465 km.
1979-25B, inclination is 95.78°.
1979-39A, Progress 6 re-entered 1979 Jun 9.80, lifetime 27.62 days.
1979-59A, Progress 7 perigee on the second orbit listed should read 360km.
1979-84, launch date should read 1979 Sep 25.82.
1979-102A, Cosmos 1147 was recovered 1979 Dec 26.3, lifetime 13.8 days.
1979-103A, Soyuz T (1) was recovered 1980 Mar 25.91, lifetime 100.39 days.
1979-106A, Cosmos 1148 was recovered 1980 Jan 10, lifetime 13 days.
1980-13A, Cosmos 1164 was a Molniya failure; delete the previous amendment.
1980-34A, Cosmos 1176 ocean survey satellite's nuclear power source was boosted to the following orbit on 1980 Sep 9: 873×970 km, 64.84 deg, 103.45 min.
1980-55A, Progress 10 was de-orbited 1980 Jul 19.09, lifetime 19.89 days.
1980-41A, Soyuz 36 was recovered 1980 Jul 31.636, lifetime 65.872 days.

CORRESPONDENCE

Disposal of Nuclear Waste

Sir, Concerning the disposal of nuclear waste in space it may interest readers to know that during recent Congressional hearings in the United States, R. D. Ginter, the Assistant Associate Administrator for NASA's energy division, stated that both NASA and the US Department of Energy (DoE) had studied the possibility of using space for nuclear waste disposal.

The NASA/DoE investigation considered many disposal points including the lunar surface as mentioned by D. H. Hinson (*Spaceflight*, April 1980). Regarding this method of disposal, Ginter pointed out that NASA had already picked a suitable "dumping ground" on the lunar near side. It is the 40 km wide crater BILLY (14S, 50W), to be found on the southern edge of *Oceanus Procellarum*. This location was chosen because of its remoteness from "interesting lunar formations which might be explored at a later date".

KEITH T. WILSON,
Blackwood,
Lanarkshire,
Strathclyde.

To the Executive Secretary:

Sir, May I express my most sincere thanks to you for giving me such a warm welcome and tour of the new BIS Headquarters Building during my visit to London last June. I enjoyed the visit very much and my only regret was that it was so short. I was on business at the time and only had a few hours stopover in London before returning to Ireland.

I enclose £5 for the Development Fund.

JARLATH CONERNEY,
Technical Wing,
Irish Air Corps,
Baldonnell,
Co. Dublin,
Ireland.

Clones at Work?

Sir, I'm still shaking my head in amazement at the amount of work you all did on the buildings, as well as getting the *Journal* and *Spaceflight* out. Tell me, really, you had yourselves cloned, didn't you? While I was talking to you, there were at least six identical versions working away in some of the other rooms? It seems the only explanation.

DR. PETER MOLTON,
Battelle,
Pacific Northwest
Laboratories, Richland,
Washington, USA.

From strength to strength

Sir, I was surprised to read about the goings-on at the 34th Annual General Meeting (*Spaceflight*, June 1980).

As far as I'm concerned, all of you on the Council Staff have done a tremendous job of organization and fund raising in setting the Society up in its own Headquarters. The BIS can only go from strength to strength now. I'm really looking forward to seeing the H.Q. myself before too long.

DR. W. ALLAN,
Petone,
New Zealand.

Soviet Space Puzzles

Sir, During the past two years there has been much speculation on certain mysterious Cosmos missions, apparently related to the Soviet manned space programme. The whole topic is based on very few facts and the correct combination of the pieces of the puzzle is not yet clear. It may be helpful to summarize the relevant Cosmos flights[1] and their probable relationship to manned missions. Included in the list are some Soyuz and

Progress missions and reports concerning development work on manned vehicles.

(Key: C=Cosmos, S=Soyuz, P=Progress; R=object was recovered).

Object	Launcher	Launch date	Lifetime (days)	Explanation of the mission (variable probability)
C613	A2	30.11.1973	60 R	Long-duration test flight of Soyuz.
S.18B	A2	24.5.1975	63 R	Soyuz/Salyut long-duration flight.
C.772	A2	29.9.1975	3 R	Test for extended independent flight of Soyuz.
S.20	A2	17.11.1975	91 R	Soyuz/Salyut long-duration test, two-day rendezvous.
C.869	A2	29.11.1976	18 R	Progress test or 3-man (4/3/3) Soyuz test (unmanned).
C.881/ 882	D1	15.12.1976	<1 R? <1 R?	Kosmolyot (shuttle) test?
C.929	D1	17.7.1977	200/30R?	Refuelling test or space-tug-test.
Salyut 6	D1	29.9.1977	in orbit	Orbital laboratory.
P.1	A2	20.1.1978	19	Supply ferry for Salyut 6
—	—	20.3.1978		*Av. W. & Space Tech.* reported drop-tests of delta-winged vehicle from Tu-95 aircraft.
C.997/ 998	D1	30.3.1978	<1 R? <1 R?	Kosmolyot-test?
C.1001	A2	4.4.1978	11 R	?
—	—	8.1.1979		*Av. W. & Space Tech.* reported construction of long runway at Tyurataum.
C.1074	A2	31.1.1979	60 R	Probably a long duration test of a new Soyuz (4/3/3) variant.
C.1100/ 1101	D1	23.5.1979	1 R? 1 R?	Kosmolyot-test?
—	—	Sept./Oct. 1979		Continuing rumours that the Kosmolyot-mini-shuttle will probably be ready for manned flights in 1980.
—	—	Oct. 1979		Report from *TASS* that a Hungarian cosmonaut will accompany Soviet crew on next manned mission in 1980. The formulation of the statement may imply that it will be a crew of more than 2.

From the table we see that there is a clear division of the missions into two sets, the first being launched by the A2 and the second by the D1. With a maximum payload of about 7200 kg for the A2, these tests are clearly related to Soyuz and Progress development work. It seems extremely improbable that a Kosmolyot-vehicle with a mass of only about 7 tonnes can be constructed or will have an interesting man- and/or payload-carrying capability. (In the CNES-study for a mini-shuttle, "Hermes", a mass of 9.5 tonnes was estimated as necessary). A very interesting mission, using the A2, was the flight of Cosmos 1074. As in the case of Cosmos 613, a vehicle was tested in orbit for 60 days. Because this mission was conducted after successful Progress flights, a long duration test of a cargo craft is improbable and would not be very useful, since the Progress is not able to return to Earth. Based on this assumption, it appears to me that a new version of Soyuz, probably the (4/3/3)-variant, was tested. If this is correct and if the test was successful (it seems that it was), this new Soyuz-variant may be used in the near future.

Explanations for the nature of the Cosmos-missions using the D1 launcher are far more speculative.

Concerning the mission of Cosmos 929, a broad variety of opinions were printed in *Spaceflight*, including my own speculations. I think now, that the ideas of Mr. R. F. Gibbons are probably correct. He wrote in[2] that the flight of Cosmos 929 was connected with a refuelling test in orbit using a stripped down Salyut and a Progress craft. The speculations derived from significant orbit changes of Cosmos 929, became more improbable last year. A Progress craft made a major orbit change of the Progress-Salyut-Soyuz-complex to 399×411 km.

The most obscure missions are the dual payloads C.881/882, C.997/998 and C.1100/1101. For all three, the lifetime in orbit was very short, the vehicles being deorbited after one or only a few revolutions. Two points are not clear in in this context: (a) was there only one orbit or was there a progressive sequence in the number of orbits? (b) Is it certain that all the vehicles were returned to Earth or was possibly only one craft returned on each mission, and the other one burned up in the atmosphere? The answers are probably crucial for solving the mystery.

Despite all questions, I am inclined to connect these missions with the Kosmolyot development programme. In an Austrian newspaper[3], there is a report of an interview with Prof. Hermann Kölle. The reporter, Dr. Hofstätter, wrote that a Kosmolyot-vehicle will make a manned test flight, very probably next year. This delta-winged craft has a wing-span of about 15 metres and is much shorter than the US-shuttle. (This implies a sort of enlarged Dyna-Soar). The craft has no payload bay; it may be able to transport four (or even six) people and will be orbited with an expendable launcher (probably the D1). The report states that cosmonaut Georgi M. Greshko explained that a craft similar to the US Space Shuttle will not be used in the near future because such a vehicle would become economical only if 20 to 30 missions were flown per year, and that was not useful in connection with the Soviet space station programme.

From all these facts and speculations, I would make the following (speculative) conclusions:

1. There is a Soviet development programme for a small reusable craft, the Kosmolyot. Manned test flights may begin in 1981.
2. A new Soyuz variant, probably the (4/3/3)-version for a crew of three, was tested in the last two years. It may emerge as a manned craft very soon, possibly in the next manned flight.
3. At first glance, it seems doubtful that the USSR is developing at the same time a new Soyuz-variant and a (small) reusable craft, but there are some important circumstances to remember.

The technology of Soyuz-type vehicles is well proven; for a new variant there are no new problems regarding the reentry sequence. The development costs are relatively low and the craft can be launched with the relatively cheap A2 launcher.

On the other hand, the development of the Kosmolyot involves new technology, a difficult reentry sequence and the necessity to use the D1 launcher. Manned test flights with the Kosmolyot will probably cover some years before it will become operational. If in this period an extended Salyut-programme is conducted, a bigger crew of the Soyuz may be necessary. Using modified Soyuz and Progress vehicles, a vigorous Salyut programme can be carried out, totally independent of the Kosmolyot programme.

The mystery of the development programme remains, but a clear statement from the Soviets may make all speculations obsolete.

NORBERT GIESINGER,
Vienna, Austria.

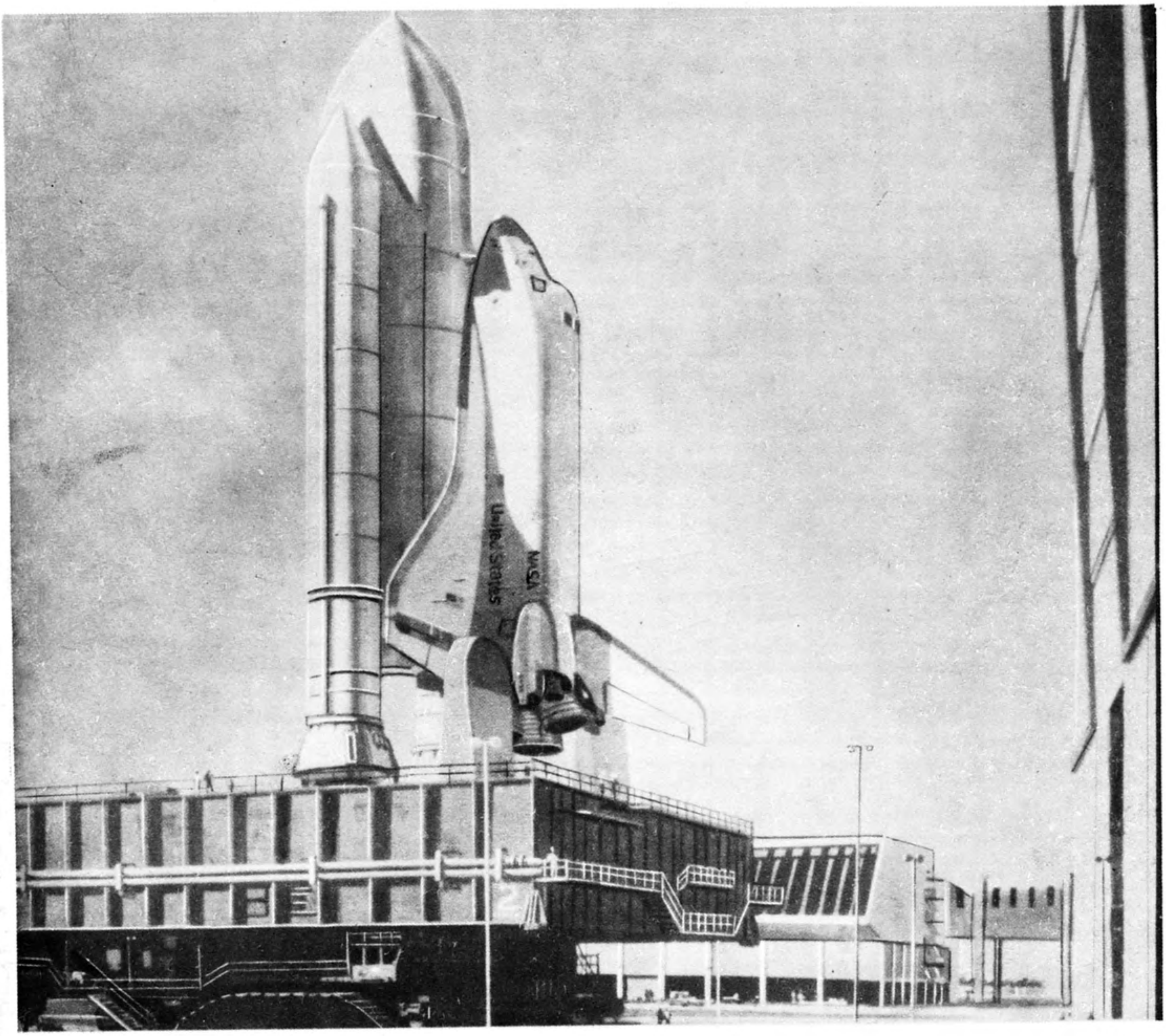
REFERENCES

1. Satellite Digests, *Spaceflight*, 1977–1979.
2. *Spaceflight*, July 1978.
3. Salzburger Nachrichten, 30.10.1979.

ISSN0038-6340

SPACEFLIGHT

88905 Космические полеты № Т-2
(спейсфлайт)
По подписке I98I г.



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THE BRITISH INTERPLANETARY SOCIETY
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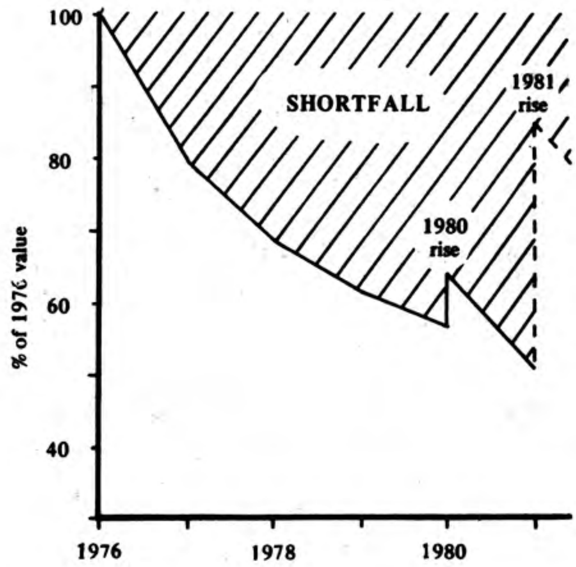
(h) Remittances from Europe can be made by GIRO: this is the easiest and cheapest method of transferring funds. Our GIRO account number is 53 330 4008.

Space Transportation Working Group Members having technical expertise in space transportation systems and who are prepared to participate in a Discussion Group should contact the Executive Secretary for further details.

BIS subscription rates for 1976-81



BIS subscription rates for 1981 are less *than those of 1976 in real terms.*

The graph shows how inflation over the last five years has reduced the purchasing power of membership income to 50% of that in 1976. The shaded area represents the accumulative shortfall in Society income over this period. It is seen that the 1981 rise in subscription rates only partly compensates for the effects of inflation. **This increase has become necessary in order to maintain services and publications to members. Please give the Society your support by returning the Membership Renewal Form as soon as possible.**

THE SOCIETY'S LIBRARY: OUR NEED FOR BOOKS

Dear Member,

We are undertaking a substantial effort in endeavouring to build up a Specialised Space Library for the Society, though our efforts are greatly hampered by the fact that, in a period of rapidly-increasing inflation, the Society has no funds available for the purchase of books. This is why we need to rely solely on the goodwill of our members to help us acquire suitable material.

To support this Appeal, the Library Committee has asked me to write to each member of the Society who is known (or suspected) to be an Author of books of the right calibre on astronomy and space, to place our Appeal before them and seek their help, especially because the Committee particularly wishes to see that all relevant books published by members of the Society, even if they first appeared some years ago, appear on our shelves.

The Committee seek your support and hope that you will be willing and able to donate one or more copies of your works. Needless to say, if you have duplicates of any other material which you could consider parting with and donating to the Society, they would be extremely grateful for this too.

I hope you will be able to respond favourable.

L.J. CARTER
Executive Secretary

SPACEFLIGHT

A Publication of The British Interplanetary Society

VOLUME 23 No. 2 FEBRUARY 1981 *Published 15 January 1981*

Editor
Kenneth W. Gatland, FRAS, FBIS

CONTENTS

COVER

THE MAIDEN FLIGHT. Activity is now running high at the Kennedy Space Center where final preparations are being made for the first flight of the Space Shuttle 'Columbia'. The launch had been provisionally set for March 1981 by Dr. Robert Frosch, the former Administrator of NASA, last August. After 'Columbia' left the Orbiter Processing Facility, a 15-week work schedule was establishing leading to an earliest launch date of 10 March. To achieve this 'Columbia' had to be moved first to the Vehicle Assembly Building where it would join the Solid Rocket Boosters and External Tank to undergo an integrated test in preparation for its 3½ mile journey to Launch Complex 39A. It was then to undergo another extensive series of tests to assure compatibility between flight and ground systems in preparation for the Flight Readiness Firing, scheduled in February. The firing, during which the main engines operate for 29 seconds, with the vehicle held down on the pad, would constitute both a validation of systems readiness and a full dress rehearsal of the actual countdown.

NASA

MILESTONES

October 1980

1 Royal Society announces that a Memorandum on the subject of U.K. space activities has been submitted to H.M. Government. A group under Sir Harrie Massey which included the Treasurer and Physical Secretary, prepared the document which was submitted on 5 September. The Memorandum proposes the establishment of a National Council for Space with the following role:

(a) to review existing and proposed U.K. domestic space activities and to evolve a broad and coherent strategy within which they may be realised to the maximum commercial, social and scientific advantage of the United Kingdom;
(b) to consider likely future developments in space technology and their potential and to advise Government, industry and other agencies accordingly;
(c) to define, and advise Government on the United Kingdom's role in the European Space Agency and other international collaborative projects in space; and
(d) to ensure any necessary coordination of effort not otherwise being achieved. The Royal Society's Memorandum stresses the very considerable commercial and scientific potential of space technology which should be exploited to secure maximum advantage to the United Kingdom. The present U.K. efforts in space science and technology are fragmented and there is a serious lack of cohesion to such an extent that there appears to be no overall domestic space policy.

BIS recommendations submitted to H.M. Government in November 1972 raised similar questions regarding lack of coordination in U.K. space activities.
(Quote) **"In this country, space responsibilities have traditionally been divided between a number of Ministries, on the basis of 'user' interests (Fifth Report of the Select Committee on Science and Technology, para. 8). There is not a British space programme as such, but only an assemblage of user projects co-ordinated by some undisclosed Cabinet machinery, which does not lead to any publicly discernible line of policy in relation to space as a whole."**
See "Spaceflight", January 1973 pages 34-35: "The Urgent Need for a United Kingdom Space Authority".

The Society first urged the creation of a UK Space Authority to coordinate national space effort and ensure adequate representation in international programmes in a Memorandum to HM Government in April 1965. The same basic proposal has since been repeated many times by other bodies. Ed.

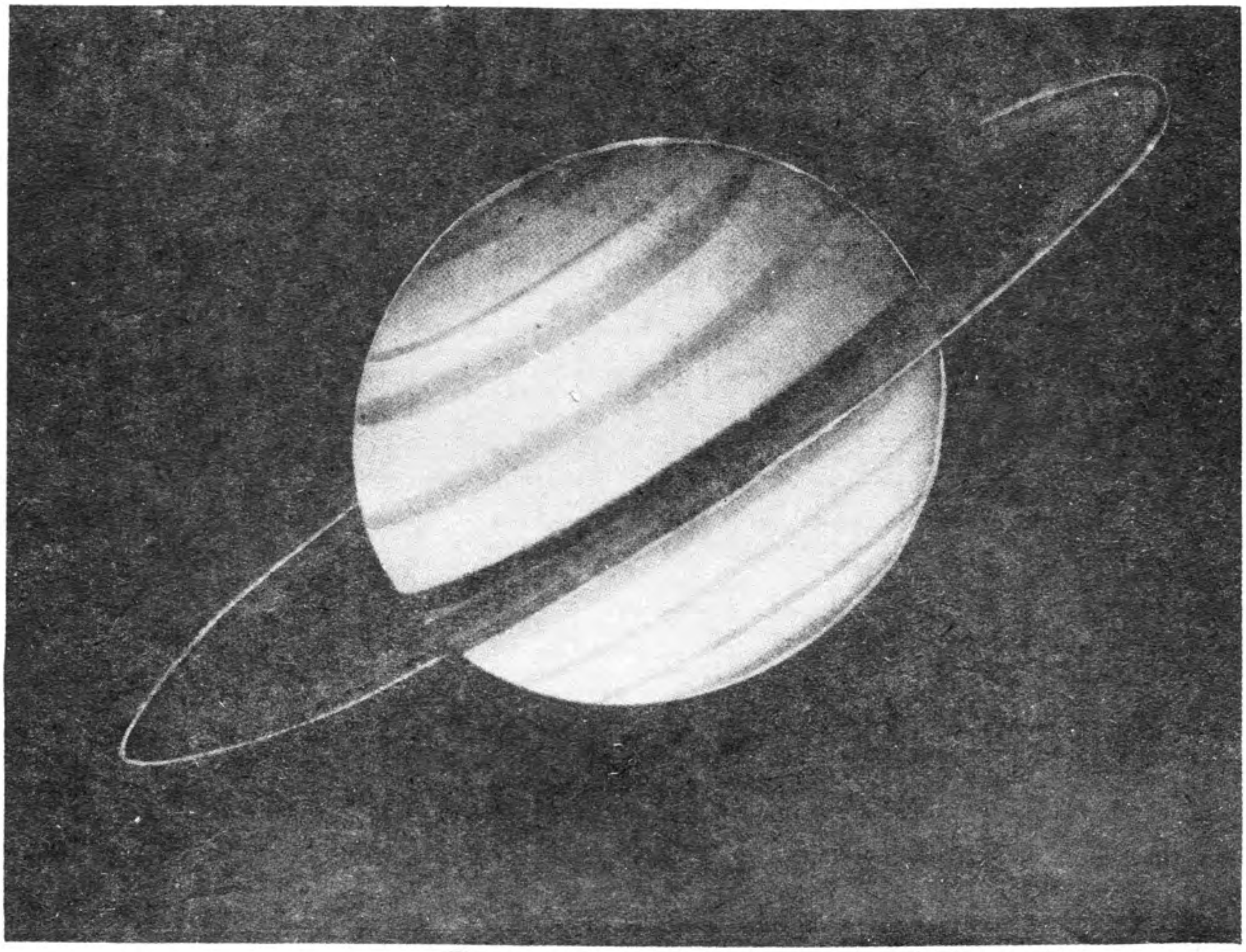
10 Jet Propulsion Laboratory completes final trajectory corrections which ensures that Voyager 1 will pass within about 77,000 miles (123,920 km) of Saturn's cloud tops on 12 November.

22 Voyager 1 photos of Saturn from 32 million miles (51 million km) show dark spoke-like regions in the rings which retain their form for several hours.

23 ESA announces that the launch of Ariane 03 at Kourou, French Guiana, will take place no earlier than 20 March. This follows a postponement from November 1980 resulting from the loss of the second flight vehicle in May and the subsequent enquiry. The problem was traced to combustion instability in one of the first stage engines 5.75 seconds after ignition. Damage to the injector led to the engine's destruction 64 seconds later and started a fire in the engine bay. This fire caused the breakup of Ariane 108 seconds after lift-off. Engineers have now tightened up on injector manufacturing tolerances and static tests of each Ariane engine will be made before the next launch which will carry the geostationary satellites APPLE and METEOSAT 2. French rocket engines say the combustion instability was caused "by an unfavourable combination of manufacturing tolerances in the system which injects fuel into the combustion chamber. The problem did not show up in nearly 200 static engine tests, which indicates the subtlety of the problem.

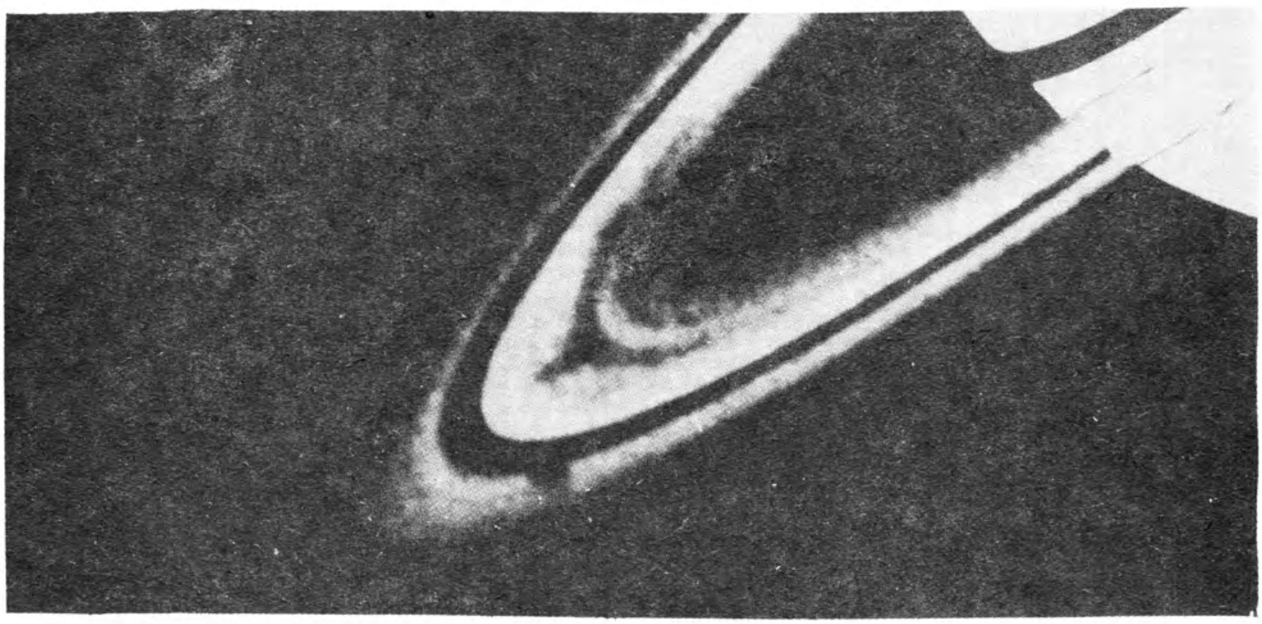
24 NASA delays launch of "Columbia" at Cape Canaveral by four days to allow more checkout time on the pad. The launch is now scheduled for 14 March 1981 (but could still be delayed a few weeks more as technical snags are ironed out).

[*Continued on page 41*]



ENCOUNTER WITH SATURN. This image of the giant ringed planet, taken by Voyager 1 on 18 October 1980, was colour-enhanced to increase the visibility of large, bright features in the North Temperate Belt. It is believed that these features resemble gigantic convective storms with upwelling from deep within Saturn's atmosphere. The nature of the dark spots, like the one visible on the northern edge of the belt, is not yet clearly understood, though they seem to resemble equally mysterious features seen on Jupiter. The largest violet-coloured cloud belt in the colour enhancement) - its true colour is brownish - is Saturn's North Equatorial Belt. The distinct colour difference between this and other belts and zones may be due to a thicker haze layer covering the northern portion of the belt. *Below,* features of the rings of Saturn that have never been seen before appear in this photograph taken by Voyager 1 on 5 October from a distance of 32 million miles (51 million km). Visible in the rings is a pattern of a dark, fingerlike appearance that rotates around the planet like spokes of a wheel. Studies of this and other photos show many similar objects. Some retain their identities for several hours, despite the fact that at the inner edge of the new features, ring objects orbit Saturn once in 9½ hours, while particles at the outer edge take more than a hour longer.

NASA/JPL



A BRIEF HISTORY OF THE VOYAGER PROJECT

THE END OF THE BEGINNING

By J.K. Davies

On 12 November one of the world's most spectacular space missions reached its climax when Voyager 1 flew behind the rings of Saturn to record with cameras and other instruments how sunlight is affected as it shines between the ring particles. The spacecraft which left Cape Canaveral on 5 September 1977 had previously returned superb colour pictures of Jupiter and a number of its moons and a wealth of scientific data. The close encounter with Saturn included an examination of the moon Titan - bigger than the planet Mercury - Mimas, Dione and Rhea.

Introduction

On the morning of 20 August 1977 the palmetto scrub round Cape Canaveral's launch complex 41 was shaken by the departure of the first of two NASA Voyager spacecraft on a journey to the outer planets and beyond. Tracing complex paths across the Solar System the Voyager project is the most ambitious planetary mission to date and, as is to be expected for such a complicated flight, the route to pad 41 was as convoluted as the journey to the edge of the Solar System will be. In this article the evolution of the Voyager spacecraft is traced from its beginnings in the Grand Tour missions of the Sixties to the 808 kg spacecraft nestling on top of a Titan Centaur rocket at Cape Canaveral.

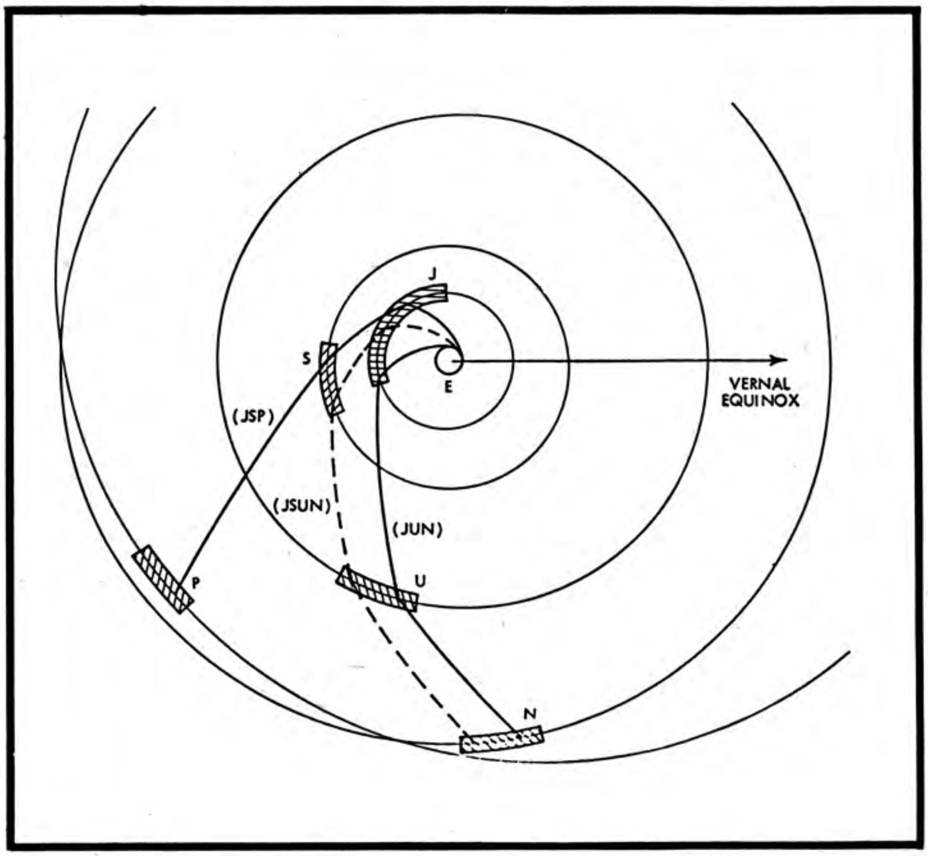
The Grand Tour

In 1925 Hohmann [1] advanced the idea of using the gravitational field of a planet to alter the trajectory of a passing spacecraft but it was not until the mid-Sixties that developments in interplanetary spacecraft focused attention on the science of astrodynamics. In 1963 Minovich [2] presented the detailed analysis of a gravity assisted mission trajectory to the inner planets from which developed the 1973 Mariner 10 flight and a year later Hunter suggested the gravitational field of Jupiter could be used to reduce the flight time to the outer planets [3].

At first it appeared that new guidance technology would be required to make such missions possible but studies by Sturms and Cutting showed that existing techniques were adequate. Garry Flandro [4,5] while carrying out post-graduate studies at JPL, discovered that a mission using the gravitational field of Jupiter to accelerate a spacecraft to Saturn and then to use Saturn's gravity to go on to Uranus and Neptune was possible during the period 1976-1978. The title given to this daring proposal was the 'Grand Tour'. The original concept involved a 1977 launch arriving at Jupiter in 1979; from here the spacecraft would be accelerated by 11 km/sec and its course deflected by 97 degrees towards Saturn, where it would arrive in 1980. From Saturn the spacecraft would proceed to Uranus in 1984 and then on to a 1986 encounter with Neptune.

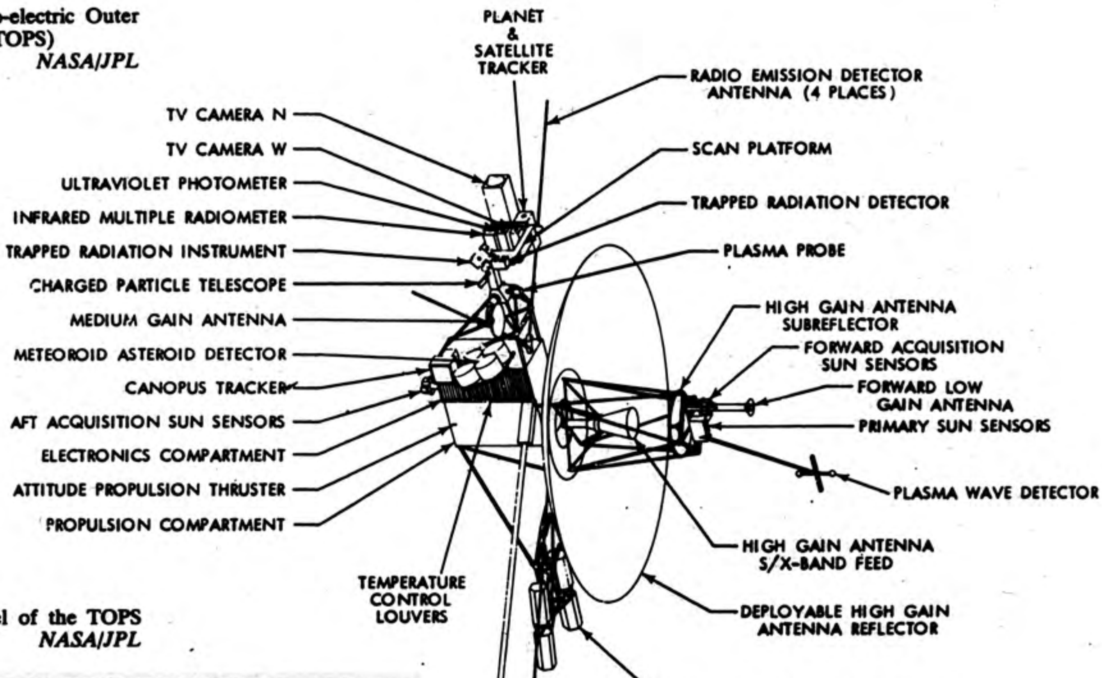
Unfortunately the celestial mechanics of this flight would require passage very close to Saturn where considerable danger to the spacecraft could be expected from impacts with the particles which constitute Saturn's rings. A more conservative approach was detailed in a 1969 paper by James Long [6] of JPL's advanced projects office, using two spacecraft both on courses which kept them clear of Saturn's rings.

The first flight, GT 1, would be launched in August 1977 to fly past Jupiter 17 months later, this spacecraft would arrive at Saturn in August 1980 for a final deflection onto a five year four month coast to Pluto in 1986. The role of Saturn in this mission is not to change the velocity of the spacecraft appreciably but rather to bend the trajectory up by almost 25 degrees, out of the ecliptic, to meet Pluto which in 1986 will be over 1¼ billion

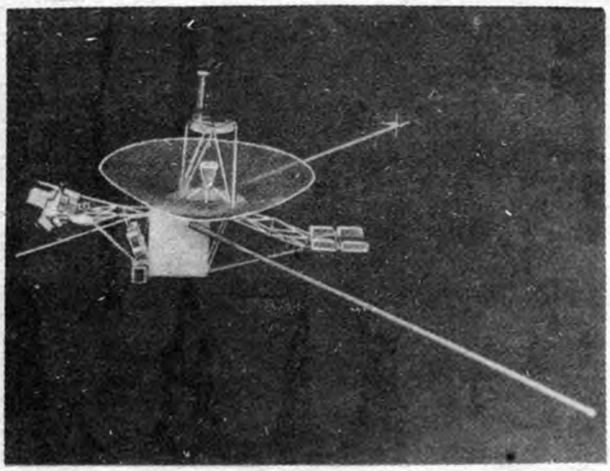


1976-1980 Grand Tour Mission Possibilities. *NASA/JPL*

Right: The Thermo-electric Outer Planets Spacecraft (TOPS) *NASA/JPL*



Below: Scale model of the TOPS spacecraft. *NASA/JPL*



km above the plane of the Solar System and closer to the Sun than the planet Neptune. Grand Tour 2 would be launched later, in November 1979 to encounter Jupiter in 1981, Uranus in 1985 and Neptune in 1988.

Long identified 1977-1979 as the vintage years for launching Grand Tour missions, pointing out that this period allowed flight times to the outer planets to be reduced considerably without the necessity for launch vehicles beyond existing capabilities. It is interesting to note that he proposed the use of Titan Centaur rockets which were not then available. Although the Grand Tour itself had not received funding at this time work was underway on the spacecraft and computers which would be required for such a mission.

THE TOPS Spacecraft (7)

By 1967 NASA had flown three successful interplanetary missions, Mariners 2, 4 and 5, and no spacecraft had flown beyond the orbit of Mars so it was obvious that much engineering development would be needed to fulfill the demands of a 10 year Grand Tour mission. Some consideration of the advanced type of spacecraft required for such a mission had been given by Long in his original proposal and from these the staff of the JPL carried out a detailed study of the type of vehicle required for such a flight. The name given to the study was TOPS, reflecting both the nature of the proposed mission and the technology underlying it, TOPS was a contraction of Thermo-electric Outer Planets Spacecraft.

The TOPS study was not a final design for a specific space mission but was organised as an advanced systems development exercise to define the limits of existing technology and to advance the state of the art where necessary.

The project was to consist of:

(1) The design of the complete outer planet spacecraft.

(2) The design, fabrication and test of certain hardware elements for subsystem capability demonstrations.

(3) The fabrication of a Feasibility Model spacecraft to demonstrate the required advanced technical capability.

(4) A test programme to explore interactions between subsystems and demonstrate the design concepts.

(5) A Reliability and Quality Assurance effort to provide a basis for future project assurance activities.

At the completion of a six month project definition in December 1968 the R & D funding was estimated to be 17.5

million dollars. In October 1969 when the concept was better understood the cost of hardware development was estimated to be 7M in FY70 and 10M in FY71 so a less ambitious plan deleting the feasibility model was selected. Some of the funds for the reduced project did not materialise on time so a further 4M was granted to allow an extension into FY72. This permitted a number of efforts to reach fruition and brought the final cost to about 21 million dollars [8].

The accomplishments of the project varied in nature some being only paper studies and others being major working models, known as breadboards. Although the feasibility model was dropped some system interactions were investigated separately and developments in microelectronic components served as vehicles to advance reliability technology. At the end of this major design effort it was possible to describe in some detail the type of spacecraft envisioned but the description which follows represents only one of the possible configurations of the TOPS.

The requirement for a 3657msec − 1(12,000 ftsec − 1) departure velocity limited the spacecraft weight to about 680kg (1500lb) if existing launch vehicles were to be used and the final configuration of the TOPS weighed 656 kg (1446 lb) of which 117 kg represented the weight of four Plutonium 238 Radioisotope Thermoelectric Generators (RTG's) used to provide electric power during the mission. The power-to-weight ratio of RTG's becomes more favourable than that of solar cells for deep space missions because the diminishing amount of sunlight beyond the orbit of Mars requires the use of increasingly large collecting areas. These nuclear power sources were to be positioned at least 1.5 metres from the main spacecraft bus on deployable booms and were expected to provide 439 Watts at the end of the planned mission. The remainder of the power supply system, consisting of voltage regulators, distributors, etc., weighed 10.4 kg (23 lb).

The use of RTGs for power generation required the protection of the scientific instruments and spacecraft electronics from the radiation emitted by these devices. Although partly solved by positioning the RTGs on the booms additional protection was achieved by shielding and by the hardening of the components to the twelve year integrated dose from RTGs at a distance of 1.5m. Radiation protection allowing a close flypast of Jupiter was included to permit flexibility in the type of missions able to be flown.

It was estimated that to be able to detect the transition from solar to inter-stellar magnetic fields the magnetometer would need to be removed at least 8.5m (25ft) from the rest of the spacecraft and so this and the plasma wave detector were mounted on a boom 9.2m (30ft) long. To maximise their field of view other scientific instruments, including the cameras, were also carried on booms. Studies were made to confirm that these booms would not render the vehicle dynamically unstable.

The spacecraft was to be stabilised in three axes using the type of Sun and Canopus sensors developed for earlier Mariner missions, but unlike the Mariners the TOPS attitude control system was to be based on reaction wheels. By storing momentum in a rapidly spinning flywheel and tapping it off again when required a considerable reduction in the number of thruster firings needed during the long mission could be achieved. This reduction in the propellant mass required was sufficient to compensate for the additional weight and complexity of the reaction wheels. Only when these became saturated would a monopropellant hydrazine thruster be used to unload surplus angular momentum.

For midcourse trajectory corrections a 110 Newton thrust hydrazine engine would provide a total ΔV of 220m/sec, one and a half times the expected total impulse requirement for a Grand Tour mission.

For communication purposes a 4.3 metre diameter high gain antenna was considered necessary to support a data rate of 2048 bits per sec (bps) from the distance of the planet Neptune. The antenna was carried into orbit in a stowed configuration and deployed when the spacecraft had separated from the launch vehicle's final stage. The design of this antenna proved to be a major challenge since to ensure maximum efficiency at long range it should accurately deploy to maintain the correct shape. Throughout the mission the antenna would be subjected to temperature gradients and micrometeor impacts both of which would tend to cause distortion. Studies indicated the need for approximately 48 ribs and suggested the use of a tricot knit of 0.017mm (0.0007in) Chromel-R alloy, gold plated for RF reflectivity. This was similar to the RCA developed high gain antenna used for the Apollo ALSEP.

The data rate was chosen to allow 400 pictures, each of five million bits, to be returned from Neptune over a period of 11 days. This set a correspondingly higher rate of data return for the nearer planets because of the reduced communication distances.

Two redundant 10^9bit tape recorders were included in the payload for use during encounters with the planet Saturn and beyond. At Jupiter, except during the period of Earth occultation, the 131,072 bps data rate available would allow realtime transmission of all science data. In the event of both tape recorders failing a 10^8 bit buffer could be used either to maintain the imaging experiments or for storage of most of the data from the other instruments.

The TOPS was intended to carry five S-band and two X-band transmitters for data return, although the X-band is only usable if the ground station has good clear weather. To provide extra redundancy two of the S-band transmitters used solid state amplifiers, the other three having the travelling wave type.

A refinement to reduce tracking and data acquisition costs for this mission was the storage of science and engineering data on board for transmission at weekly intervals during the interplanetary cruise. This technique had been used by earlier Soviet spacecraft but not by any American probes so far flown.

The 'Star' Concept

With planned Grand Tour durations of the order of ten years the reliability of the spacecraft became of critical importance and improvements in subsystem lifetimes a major development task. In view of the complexity of the missions and the long communication lags as the spacecraft recedes from Earth it was considered essential that the spacecraft be capable of operating unsupervised for long periods. This required an onboard computer of hitherto unknown complexity, compounding the likelihood of a computer malfunction. Since the failure of the onboard computer could cause the mission to be lost, or at least seriously degraded, a means had to be found to protect against this contingency. Although spacecraft computers have now reached such a high standard of reliability that to date no interplanetary mission has been lost due to computer failure the state of the art in the Sixties was such that the possibility of a major computer failure during a ten year flight could not be ruled out. Thus came about the idea of a computer able to identify failures within itself and to take any action necessary to restore itself to full efficiency.

This concept, originally advanced by Dr. Alverez Avizienes of the NASA JPL was known as STAR, an acronym for Self Testing and Repair. In 1965 Dr. Avizienis, assisted by Allen Weeks and David Reynolds designed the first working model of a STAR computer and by 1969 a ten unit computer able to diagnose errors and effect a cure in 1/100th of a second had been built. [9] This unit was large, it occupied three 1.8 metre equipment racks, but would have been miniaturised to fit the weight and power requirements of a spacecraft.

The system was designed so that in the event of a failure within the computer the messages between the various subsystems would be 'corrupted', i.e. illegal words would be generated by the failing unit. These illegal words would then be

detected by the Test and Repair Processor (TARP) which identifies the area of the failure and switches in a replacement unit. The TARP itself is a triplex unit, with three active monitors voting on each decision. If one of these dissents it is tested and, if it continues to disagree with its companions, it is removed from the system and replaced by back-up unit. Thus, in addition to monitoring the computer the TARP is able to check on itself, and by comparing samples from the downlink telemetry to critical values stored in its memory, the condition of the rest of the spacecraft.

Although developments in solid state microelectrics have improved computer reliability such that no STAR type computer has yet been used on an interplanetary mission, the development of such a system for the increasingly complex planetary and ultimately interstellar missions of the future seems inevitable.

Probing Jupiter's Atmosphere [10]

As the Sixties drew to a close the Martin Marietta Corporation had been studying the possibility of delivering a scientific payload deep into Jupiter's atmosphere.The entry probe was to have been carried to Jupiter on a Pioneer or TOPS type bus and the detailed objectives would depend on the vehicle employed. The Pioneer mission was planned to carry a 12.3 kg payload to a depth at which the pressure rose to 72 Earth atmospheres whereas the TOPS payload of only 8.6 kg would penetrate to a depth of 300 atmospheres.

For the TOPS mission the probe was to be released 40 days and 26 million km from Jupiter and would enter the planet's atmosphere with a relative velocity of 50 km/sec. The descent to the design depth, slowed by appropriate drag devices, was expected to take about 2½ hours and when the pressure had risen to 300 atmospheres, probably about 400 km below the cloud tops, the basic mission would be complete. The overall design of the probe would probably have been similar to the recent Pioneer Venus probes, having a spherical pressure shell protected by an aeroshell. The provisional science payload included a small mass spectrometer, accelerometers, a photometer, temperature and pressure sensors and possibly an optical flash detector to search for lightning.

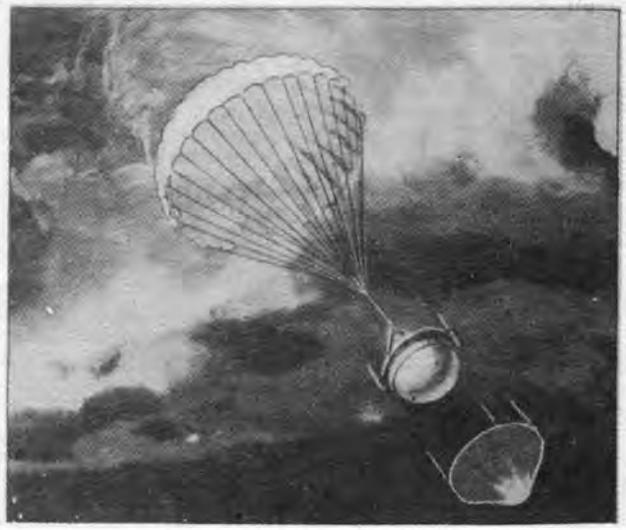
With the Grand Tour under active discussion it was logical to consider combining the two flights and releasing the probe from one of the Ground Tour spacecraft. Unfortunately, further studies showed that because of the different approach trajectory a single stage probe could only survive to a depth of approximately 10 atmospheres. To achieve a greater penetration depth a two stage probe was suggested but inevitably this led to an increase in weight. To deliver the heavier probe without jeopardising the gravity assist to Saturn would have meant increasing the flyby distance and this would in turn had had a considerable effect on the other scientific objectives.

The planners of the Grand Tour were thus faced with the task of reaching a compromise between these conflicting requirements as well as the heavy workload involved in defining the basic mission.

The Grand Tour is Cancelled

As the planned Grand tour grew in complexity, one proposal included orbiters and entry probes at both Jupiter and Saturn, the estimated cost of the project grew rapidly towards a figure of 900 million dollars. Consequently when NASA requested funds for a start on the mission in FY72 the proposal was not popular with budgetery officials and the U.S. President's 1972 budget request did not include funds for the mission. The official announcement of the cancellation was made on January 24th 1972 [11].

However, the work of the planners was not to be wasted completely for John E. Naugles, Associate Administrator for Space Science, announced before a sub-committee of the House of Representatives committee on Science and Astronautics the creation of a new project, a "mini Grand Tour" based on Mariner type spacecraft and costing only 360 million dollars [12].



A recent proposal for a Jupiter probe (Project Galileo) ***NASA/JPL***

Work on a reduced programme had begun in January 1972 but the new project was not officially approved by NASA until the Contractual Task order was signed on 18 May 1972. The Project approval document was signed on June 3rd 1972 and finally the project plan was signed on 8 December of that year [13].

Although some of the scientific community were disappointed by the cancellation of the Grand Tour the U.S. National Academy of Science declared itself completely behind the new project, which was to be named Mariner Jupiter/Saturn.

Mariner Jupiter/Saturn

To keep the MJS77 within its budget, vital since NASA was already suffering financial cutbacks and more appeared likely in the near future, it was decided to use Mariner design and experience wherever possible and to supplement this with subsystems designed for the Viking orbiter to provide the required performance and reliability. The detailed design would be modified by information on the deep space and Jovian environments received from Pioneers 10 and 11 as they penetrated further from Earth than any previous spacecraft.

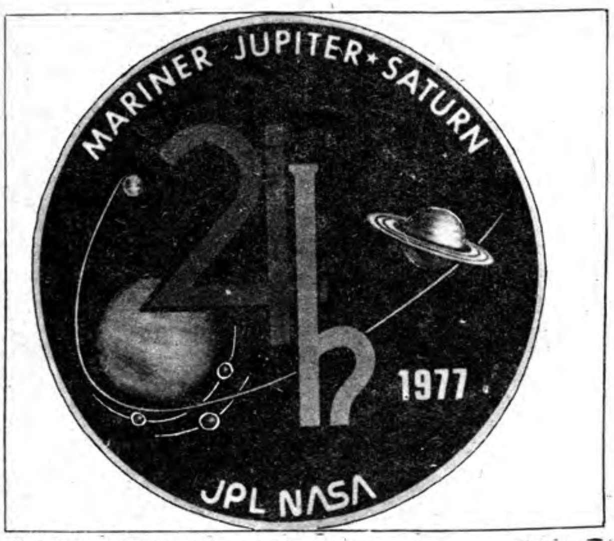
With the project now approved work commenced on specific planning of the missions and the scientific objectives of the flight were defined as comparative studies of Jupiter and Saturn through measurements of the environments, atmospheres and body characteristics of the planets, their satelites and of Saturn's rings.

Specific objectives included study of the physical properties, surface features, periods of rotation, energy balances and thermal regimes of the planets and moons and investigation of electromagnetic and gravitational fields throughout the mission. Items of special scientific interest included Jupiter's great red spot, Saturn's rings and the Saturnian satellites Iapatus, Titan and low density Rhea.

The formal request for experiment proposals was made in April 1972 and over 200 replies were received; from these ninety scientists were chosen, mainly from the U.S. but including representatives of four European countries, namely France, Sweden, West Germany and the United Kingdom.

It is not proposed to describe the MJS77 spacecraft in any detail for it is identical to the spacecraft described in references [14,15]; however, brief consideration will be given to some of the difficulties involved in such a demanding mission.

The interplanetary navigation strategy depends on the velocity vector required on arrival at Jupiter and this is at least



The Mariner Jupiter/Saturn mission badge. *NASA/JPL*

partly determined by the need for a suitable departure towards Saturn. The path through the planet's satellite system must be chosen to give the maximum scientific return based on consideration of lighting, flyby distance, occultation of planets and moons and the study of the complex electromagnetic environment surrounding Jupiter. A review of the selection process and the preliminary choices is given in reference [16]. Navigation of the spacecraft through the satellite system is further complicated by the perterbations of the moons themselves, the masses of which were not well defined during the original planning for the mission. Launch strategy and deep space navigation were also studied in great detail to achieve the best possible trajectory [17,18].

Radio astronomers had believed for some time that Jupiter possessed considerable radiation belts but until Pioneer 10 flew close to Jupiter in 1973 their intensity and spatial distribution were uncertain, so considerable effort was expended on hardening the spacecraft's delicate electronics. Test specimens were exposed to several levels of radiation from Dynamitron electron accelerators producing steady streams of electrons with energies of up to 2.5MeV. The programme was carried out to harden the spacecraft against a total dose of 5 trillion ($5x10^{12}$) electrons per cm^2 (19].

The provision of a telemetry system capable of providing high quality transmission of science and engineering data over extreme distances presented a major challenge. The evolution of the telemetry system and the predicted performance are discussed in detail in specialist publications [20] as are the attitude control requirements [21].

Another significant obstacle facing mission planners was uncertainty as to how close to Saturn's rings it was safe to fly, since opinions on both the size and density of the particles in the rings was divided. In 1970 a report commissioned by NASA implied that flying through the rings would present a negligible hazard although it was reported that NASA had already decided against such a drastic course of action. Later, in 1973, scientists at the JPL used the Goldstone antenna as a radio telescope, and by observing the reflections from the planet after bouncing 400kW beams of 12.5 cm wavelength radiation from the rings concluded that they consisted of solid particles 1 metre or more in diameter, a far from insignificant risk! [22].

So it can be seen that as detailed planning for Mariner Jupiter/Saturn got underway, although existing experience was being applied wherever possible, much new development was also required. Moreover, it should not be imagined that MJS77 was the only outer planets project under study for during the early 1970s NASA was attempting to define a strategy for the exploration of the planets which would be possible within what was expected to be a period of increasing economic stringency.

Other Outer Planets Missions

Although budgetary cutbacks had cancelled the Grand Tour nothing could change the planetary alignments and NASA still hoped to make limited use of them for other missions. One such proposal was Mariner Jupiter-Uranus, launching a back-up MJS77 spacecraft in November 1979 to flyby Jupiter in April 1981 and proceed to Uranus arriving in mid-1985. The 1979 launch was particularly favourable because of the unique approach geometries possible on arrival at Uranus. Since the planet would be pole on to the approaching spacecraft there would be an opportunity to study the high latitude regions under good lighting conditions for a prolonged period. In addition the orbits of the planet's five moons would be seen not as beads on a wire but rather as a target as Mariner sped towards rendezvous. Typical of the scientific results expected **would** be improved values of radii and masses for the planet and its satellites, unique photographs and infra-red studies impossible from Earth [23].

Other proposals based on Mariner and Pioneer type spacecraft included a Mariner Jupiter Orbiter, now developed into project Galileo, and Pioneer missions carrying atmospheric entry probes either directly to Saturn or to Uranus via Jupiter [24]. Although only the Jupiter orbiter was chosen for development Uranus was not forgotten and plans to send one of the MJS77 spacecraft on to Uranus were discussed by Robert S. Kramer, Director of Planetary Programmes, in November 1972 [25]. He described the Uranus and Neptune options and added that although not designed for this extended flight specifically he believed the spacecraft to "have a chance". Perhaps the Grand Tour was not quite lost after all.

Project Voyager

Early in 1977 work on the project was well advanced for a late summer launch but the mission that had undergone so many changes was to undergo one more. It had been felt that since the MJLS77 spacecraft had departed so much from the original Mariner family that a new name would be appropriate. A competition was held to choose a new name and the winning nomination "Voyager", approved on 4 March 1977 [26], was the name which has already earned a place in scientific history. Although apt for the flight the name was surprising in one respect: an earlier project had already used it.

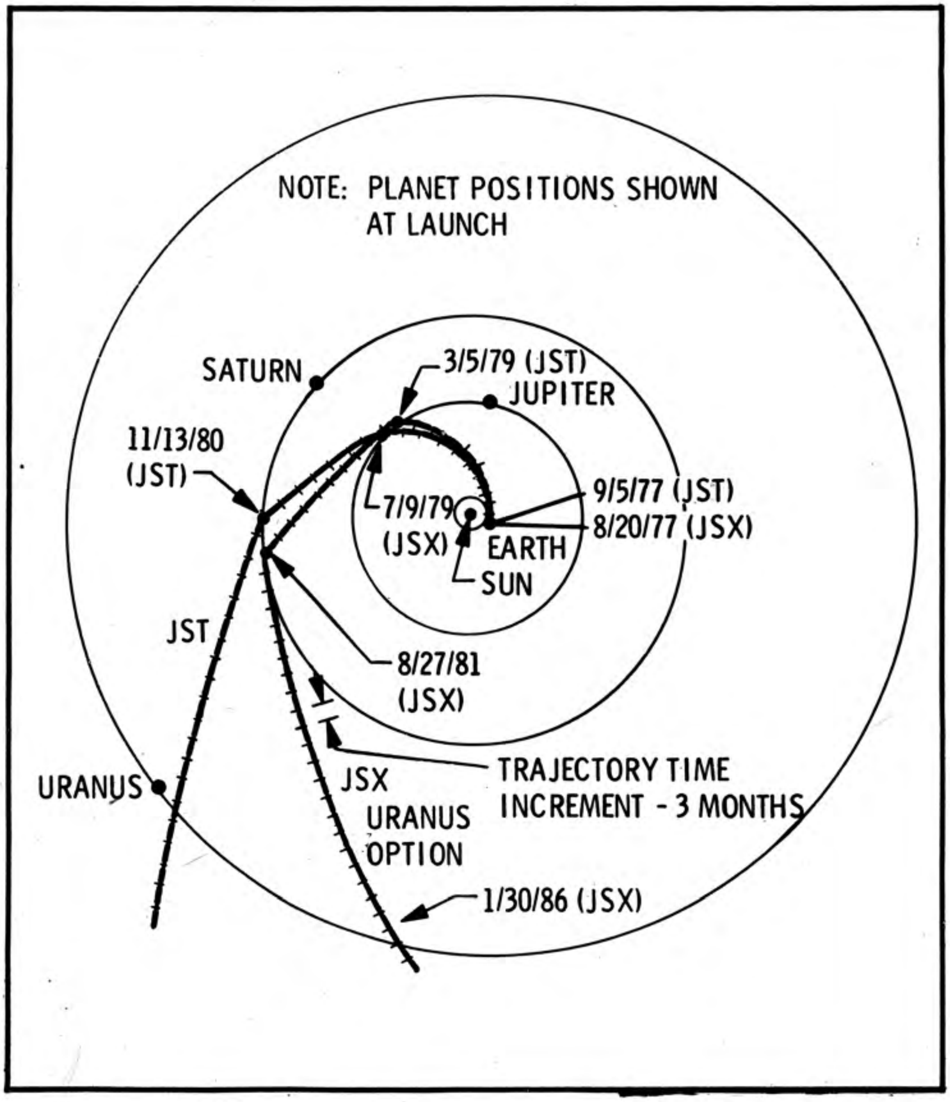
The original Voyager project was a plan to soft land instruments on the planet Mars. This little known project, involving both orbiter and lander, was similar to the Viking which succeeded it. Voyager would, however, have been larger and more expensive and its development was not proceeded with. A comparison of Voyager with Mariner 9 and Viking is given in reference [27].

This rather sudden change of name so near to the launch date did lead to a certain amount of confusion and references to Mariners 11 and 12 and even Voyagers 11 and 12 [28] are a legacy of this last metamorphosis.

Prelaunch Operations

The Preshipment Review for the spacecraft was held at the JPL on April 12/13, 1977 and the two flight spacecraft were shipped to the Cape on 21 April and 19 May 1977, respectively. The shipment required a caravan of trucks and took about four days for the trip from California to Florida. Each truck had two drivers so that only meal and fuel stops were required. The vehicles were special air-ride trucks and were instrumented to assure that no equipment damage occurred during shipment.

After the two Voyagers were delivered to Cape Canaveral they underwent extensive checking and faults were discovered in the Attitude and Articulation Control (AACS) and Flight Data Subsystems (FDS) of the VGR77-2 spacecraft. This



Left: Voyager mission profile
NASA/JPL

Below: Voyager logo
NASA/JPL

vehicle was to be launched first and to avoid a delay the decision was made to interchange the two spacecraft. Since the first launch trajectory included an option to extend the mission to Uranus the VGR77-2 spacecraft had RTGs of a higher power output and it was necessary to exchange these with the ones aboard VGR77-3.

This was completed successfully and VGR77-3 was encapsulated on 9 August 1977. Post-encapsulation checks detected a fault in the low energy charged particle experiment and the spacecraft was removed from the shroud for repairs. Re-encapsulation took place the next day and after satisfactory checks VGR77-3 was moved to launch complex 41 and mated with the Titan-Centaur TC-7 launch vehicle.

Work went ahead to identify the failures within the VGR77-2 spacecraft. The AACS problem was traced to a thermally intermittent resistor in its computer and the AACS proof test model was installed in the Voyager in its place. The anomaly in the FDS was never duplicated in tests and remains a mystery to this day.

Departure

At 10:29:45 a.m. EDT on 20 August 1977, two years to the day after the launch of the first Viking Spacecraft, VGR77-3 - now known as Voyager 2 - was launched from Cape Canaveral. At the JPL employees and contractors were able to see the launch broadcast live from pad 41. For many of them it marked the end of one major effort and the beginning of another, far greater one. The story of the journeys of Voyagers 1 and 2 to Jupiter and beyond will be given in the second part of this article.

Acknowledgements

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[*To be continued*]

MILESTONES/Continued from page 33

26 NASA confirms discovery of two new moons of Saturn from Voyager far encounter photos. They are relatively small bodies located on either side of the F-ring.

28 U.S. Defence Department reveals that four new Soviet ICBMs of a "fifth generation" are under development in USSR, two solid and two liquid fuelled. One of the latter is described as "particularly large".

November 1980

7 Another new moon is discovered near the rings of Saturn in Voyager photographs. It appears to be about 50 miles (80.5 km) in diameter. This brings the total of known moons of Saturn to 15. Scientists at JPL say many others may be present.

10 Pictures from Voyager 1 show 'red spot' some 10,000 miles (16,090 km) across in the banded clouds of Saturn. White spots are also discernible. Rings of Saturn are more homogeneous than previously believed, joined together by hitherto invisible rings.

10 European Space Agency selects British Aerospace Dynamics Group & Communications Division to head development of the Giotto space probe that will intercept Halley's Comet in 1985/86. The work will be led by the Division's Bristol factory. Total value of the contract will be about £27 million shared between European aerospace companies.

11 Voyager 1 passes within 2,500 miles (4,000 km) of Titan, the largest moon in the Solar System. Surface is concealed by thick nitrogen smog (not methane as previously believed, which accounts for less than 1%). Measured surface pressure is 2.75 atmospheres, temperature 300°F below zero. Possibly there are oceans of liquid nitrogen.

12 Voyager 1 passes within 77,174 miles (124,200 km) of the planet Saturn. The grey-green rings - seemingly composed of ice particles with some dust and rock - have hardly any gaps. Some of the rings have eccentric paths. The outer ring is "braided like a twisted rope."

SALYUT 6 MISSION REPORT - Part 5

by Neville Kidger*

Continued from November-December 1980 issue.

Over the past four years cosmonauts from the socialist countries have been training in Zvyozdny Gorodok, Moscow, for flights aboard Soyuz spaceships and Salyut orbital stations. Up to the date of this report (July 1980) five cosmonauts from these countries have made flights to the Salyut 6 space station. They were: Vladimir Remek (Czechoslovakia), Miraslow Hermaszewski (Poland), Sigmund Jähn (German Democratic Republic), Georgi Ivanov (Bulgaria) and, the subject of the first part of this report, Bertalan Farkas (Hungary). Currently in training at Zvyozdny are cosmonauts from Cuba, Mongolia, Romania and Vietnam who are to make flights shortly. In addition two cosmonauts trainees from France, Jean-loup Cretien and Patrick Baudry started training at Zvyozdny in September 1980 and Indian cosmonaut trainees are to be selected soon. In view of the growing importance of these international spaceflights it is important to illustrate the diverse and interesting goals of such flights. The flight of Valeri Kubasov and Bertalan Farkas is presented here in detail.

The late May/early June launch window was very busy, as expected, with the Soviets taking the advantage of the western landing site in Kazakhstan to allow for two flights to be made to Salyut, each of a very different nature.

In prepration for the flights to come, on 22 May, the Dniepers (Popov and Ryumin) used the Soyuz 35 SKDU to refine the flight path of the Salyut complex pending the launch, four days later of the Soviet/Hungarian crew aboard Soyuz 36.

The Hungarian cosmonaut Bertalan Farkas told pressmen before the flight that he had worked very hard to come so far and he had spent up to 6 hours per day in the Soyuz training facility at Zvyozdny Gorodok learning to master the systems of the ferry vehicle. "All these difficulties made the unique assignment more fascinating," Farkas said. Confirmation that Farkas and his commander Valeri Kubasov, call sign Orion, were to fly the mission came on May 24th from the State Commission for Space Flights. It was stated that Kubasov's experience over 2 flights was crucial to the selection.

On 26 May the duo suited up and boarded the A2 carrier rocket some 2½ hours before the scheduled launch time of 1820:40 (all times GMT). At exactly 1820:39.844 the RD107 and RD108 engines ignited and Soyuz 36, carrying Kubasov and Farkas, was put into an orbit with the parameters: height 198 x 261 km; period 88.8 minutes; incl. 51.6°. On the first orbit the Orions inspected the hermeticity of the Soyuz's various compartments and checked the performance of certain instruments. By the second orbit the checking of the radio-navigation system was completed and the docking latches had been primed. The crew were then allowed to take off their 10kg pressure suits and settle down to supper. Corrections to the trajectory, beginning at 23.00 left Soyuz 36 in a 263 x 319 km orbit with a 90 minutes period. The Orions then began their rest period. As the space crew rested their reserves, Dzhanibekov and Magyari, were at FCC where they were to act as capcoms and advisers. Valeri Rozhdestvensky (FE Soyuz 23) was the main capcom.

At 0900 (1200 MT) 27 May both the Orions and the Dniepers were due to be woken by FCC, who had granted the latter a longer rest period. Although the Dneipers were up and working on time the Orions were still in slumber at 1000. Following breakfast the Orions checked the Soyuz's systems

Valery Kubasov and Bertalan Farkas in the Salyut trainer at the Gagarin Cosmonauts' Training Center. *Novosti Press Agency*

and spoke to FCC flight director Aleksei Yeliseyev who discussed rendezvous procedures with them. After lunch, at 1600, the Orions donned their pressure suits in readiness for the final maneouvres. By now the distance between the Salyut and Soyuz 36 was about 1,400 km. At the time of the launch of Soyuz 36 Salyut was about 12,000 km distant.

At 1620 Soyuz 36's SKDU was fired to put the ferry in an orbit intersecting that of the station. By orbit 17 the distance between the two was just 20 km and the approach was initiated. At a distance of 10 km the Igla navigation system was activated as the Dniepers held Salyut in an attitude with the rear docking unit facing the oncoming ferry ship. Docking occurred at 1956 with the final mechanical linkage being accomplished at 2005. After checking the pressurisation the hatch seal was broken and, at 2301, Farkas and Kubasov crossed into Salyut to be greeted by bear hugs and traditional bread and salt by the happy Popov and Ryumin. The transfer was completed by 2305. The Orions brought their hosts several souvenirs and 10 traditional Hungarian dishes (canned, of course). In front of the TV camera the cosmonauts were read messages from the Soviet and Hungarian leaders to which the cosmonauts telegramed replies.

At the time of the transfer Salyut's parameters were: height 340.16 x 360.21 km; period 91 minutes 35 seconds. This was corrected on the 29th by 4km in apogee using the Soyuz 36 SKDU to refine the re-entry track.

Shortly after completion of the welcoming ceremonies the Orions began work on their experiments. The first job was to take samples of the station's air for analysis on Earth, an experiment called Almaz. At 0200, 28 May, both crews retired.

• *The author wishes to acknowledge the generous assistance of the staff of the Press Section of the Hungarian Embassy in the preparation of this article. The following Hungarian publications were consulted in addition to the normal list of references: Daily News, Nepszabadsag, Fold es Eg., Reppules a Urreppules.*

The next working day was to start at 1100 28 May. During their tenure on Salyut the Orions worked for between 16 to 20 hours per day with only 3 hr-day sleep to cram in all of the planned experiments which are detailed below. The visitors often performed 10 different experiments in any one day of their one week flight on the station.

Farkas introduced Popov and Ryumin to several Hungarian dishes during their 4 meal breaks every day. The average calorie intake was 3100 calories. On the menu were Hungarian Goulash, pâte de frois gras, fried pork, jellied tongue and ox tongue in aspic which the two Soviet cosmonauts voted their favourite. The mood of the two crews was business-like but jovial with a great deal of leg-pulling during off duty hours.

The Kubasov - Farkas duo spent most of their 7 days on Salyut conducting a broad range of experiments in the fields of medicine, biology, technology and Earth studies. Most of the equipment designed in Hungary and brought to Salyut by Kubasov and Farkas remained on board for further use after the joint flight. The results of the experiments were returned, where applicable, to Earth. There were 21 experiments in total but some, such as the smelting experiments were given group names.

DIAGNOST: Immediately before and after the flight the portable Diagnost equipment was used to obtain several vital parameters of the Soviet/Hungarian crew. Tests were made of their hearing threshold, temperature, blood pressure, pulse, cardiovascular and respiratory systems etc., on the 5 measuring modules of the Diagnost device which weighed 25kg.

BALATON: The 420g Balaton instrument determines the intellectual and motor performance of the cosmonauts. The device is held in the palm of the subject's left hand with two of his fingers touching two sensor plates which record the electric conductivity of the skin. Simultaneously pulse rate is measured from the forefinger. This data indicates if the task presented by the instrument has been solved easily or with difficulty. Balaton registers the subject's fatigue rate by measuring perspiration (galvanic skin resistance). During the test tasks are presented in the form of flashing numbers on a display with answers given by pressing a button. Correct and incorrect answers are totalled by a tiny computer. Eight questions are presented which can be solved in four ways, each under different loads. The total number of tasks is 32. In operation the subject, for example, pushes button number 1 and a 0 flashes on the display (the simplest task):a more difficult task is presented when the numbers 1 to 4 flash on the screen 16 times at a stretch. Response must be given to these by pressing the button corresponding to the location value. If the correct answer is presented the 16 digit "package" begins to flash faster, in quickening tempo. Response time is measured. These tasks are also combined with long and short audio signals dosed out disparately in varying rhythm to the subject *via* earphones. 6 specimens of Balaton were made, 3 for use in training, 1 for use at FCC and 2 for the flight.

INTERFERON: Interferon is produced by human cells and fulfils the purpose of protection against virus infection. Even cancer has been controlled by injections of Interferon. There is a snag, however, in that Interferon is extremely expensive to produce, even in tiny amounts. The Orions' experiment consisted of 3 parts to study the production in weightlessness of Interferon.

1. Human white corpuscle cultures and various Interferon producing substances were placed in test tubes with a two-way valve separating them. The device was then placed into a thermostat at 37°C. When the white corpuscle culture reached average human body temperature pistons pumped them into the inductor fluid influencing Interferon production. The results were frozen for examination later on Earth.
2. Interferon pharmaceuticals placed in lyophilized gel and liquid state were delivered in synthetic ampoules to assess the influence of spaceflight conditions on the anti-viral effect of Interferon production in pharmaceuticals. These drugs may be necessary to prevent latent virus infections spreading on future long duration flights.
3. Blood samples were obtained to assess the effects of weightlessness on interferon production in the body.

DOSE: Using the Pille (moth) thermoluminescent device (TLD), weight 1 kg volume 1 litre, radiation levels in 16 Salyut locations have been measured during the long flights. The TLD measures radiation levels in the 10 mrad to 10 rad range by inserting the thermoluminescent substance, contained in a glass tube, into a cavity of the detector. 30 seconds later the dosage is displayed on a screen. Readings from the TLD, which can be attached to the cosmonauts' clothes as well as the station's walls, are obtained every 2 to 3 days throughout the flight.

OPROS: (Questionnaire) In this experiment the cosmonauts are required to answer 9 set questions about their eating habits, changes in appetite, leisure time, sensory perception, mobility and need for medication in the form of drugs (2 types of drug are available for the cosmonauts as stimulants), in order to determine their psychological state. The subject's facial features are also studied.

Some of the experiments in the bio-medical field the Orions participated in were continuations of the earlier international flights' studies. The AUDIO experiment, using the GDR-made 2kg Elbe audiometer, was continued as were measurements of the oxygen content of the cosmonauts' skin tissues with the Czechoslovak OXYMETER experimental device. Other studies conducted at a low level were studies of *Drosophila* (fruit flies), fish and plant-growing experiments, which occupied the Dniepers rather more than the Orions.

In 40 sessions of visual observations and photography of the Earth the Orions conducted many interesting studies utilising the GDR-made MKF-6M camera, the 10.5 kg Bulgarian-made Spektr-15 spectrometer and GDR-made Pentacon 6M hand-held camera.

The observations centred around the study, for the compilation of a geomorphological map, of the Carpatian Basin and the Tisza River Basin. Assessment of the formation of inland waters and soil salination were the objectives of photography of the Kiskoere water reservoir and a stretch of the Danube.

In the UTROF experiment MKF-6M photos were made to assess the ecological impact on Lake Balaton, which is still regarded as clean. Simultaneous studies of pollution on vegetation on shores and open waters, particularly Keszthely Bay and the area between Tihany and Balatolmadi, were conducted from Salyut 6 (at a height of about 350 km), an AN-30 flying laboratory taking similar pictures from 6 to 7 km altitude, an AN-2 aircraft taking multispectral data in 4 bands between 1.7 and 2.7 km, IR photography from a helicopter from 1 km and meteorological data, soil and water samples from ground level.

In the BIOSPHERE experiment photos and observations were made of weather from about 100 world-wide sites for the study of the ocean and weather formations.

In atmosphere studies the Bulgarian-made Spektr-15 and Duga instruments were used in the REFRACTION experiment. This study was conducted in 2 parts called Polarisation 1 and 2. In 1 spectrographic studies were made of sunlight refraction in the atmosphere; in 2 the terrestrial horizon was studied using light filters and the VPA-1 analyser. The ZARYA experiment used spectrographic measurements of sunrise and sunset at various altitudes to determine the air density and temperatures in the stratosphere and the troposphere. Studies were made of the silvery clouds above equatorial regions but planned photography of the Falkland Current was postponed due to adverse weather conditions above the observing site.

11 separate experiments were planned in the

Soviet/Hungarian materials smelting programme. 6 were conducted by the Orions and 5 were left for the Dniepers to complete. In the Splav-01 furnace copper/aluminium was smelted under the BEALUCA experiment. The Kristall furnace was used to smelt semiconductors of gallium arsenide, indium antimonide, gallium antimonide and a monocrystal of gallium arsenide was alloyed with chromium through the moving solvent method (one of 4 techniques possible in the 28kg Kristall furnace). These experiments were part of the EOTVOS experiment named after 19th Century Hungarian physicist Lorand Eotvos. Analysis of the returned samples is expected to take up to one year to complete.

In the deformation experiment the cosmonauts studied the misalignment of optical axes caused by the 300° temperature variation between the sunlit and shaded portions of the station for navigation purposes. The results showed the misalignment to be only tenths of a degree over a 4hr. period. In the ILLUMINATOR experiment the Pentacon 6M device was used to study the degredation of the optical properties of Salyut's 20 windows due to the accumulation of "space dust" and micrometorite impacts.

Because the Orions were to return to the Earth aboard Soyuz 35, thus leaving the Dniepers the fresher Soyuz 36, they had to change their form-fitting chairs from one ship to the other and stow their results in the descent cabin. Unwanted equipment was stowed in the orbital compartment of Soyuz 35 for destruction when that module was jettisoned after retrofire.

Early on 3 June the Orions bade the Dniepers farewell in front of the TV camera. Kubasov said he felt it was a pity to return home so soon but they had fulfilled their programme. Farkas thanked the Soviet crew for its hospitality and aid. At 0620, following final embraces, the Orions crossed over into Soyuz 35 and closed the hatches. They then donned their pressure suits and checked the pressurisation. At 1147 Soyuz 35 separated from the Salyut station. Shortly afterwards a small SKDU thruster firing imparted 0.3 m/ses of velocity to the ferry and the separation distance between the station and ferry quickly widened. At 1416, some 354 km above the South Atlantic, the SKDU was fired for 179 seconds, reducing the velocity of the ferry by about 115 m/sec, to bring the Soyuz out of orbit. At 1437, some 170 km above the Sudan, the compartments of the Soyuz were separated and the descent cabin entered the denser layers of the atmosphere. Some minutes before 1500, with Soyuz into the lower layers of the atmosphere the main parachute was deployed, at about 10 km altitude. Soyuz 35 touched down safely at 1506:40 at a point about 140 km SE of Dzhezkazgan, Kazakhstan.

By the time the newsmen arrived in their recovery helicopter the Orions were busy directing the unloading of the returned equipment. The two cosmonauts, after giving some interviews at the site, were flown to Baikonur taking with them just their written documentation for traditional welcomes. Despite their long working days in space both men were well and looked happy. Farkas had lost about 3 kg. They were both given several Soviet and Hungarian State awards.

At 1638 the next day (4 June) the Dniepers undocked Soyuz 36 from the rear docking unit of Salyut 6 withdrew to about 180m distance and watched as the station was commanded to rotate 180°. Soyuz 36 was then maneouvred back to a docking with the front docking unit. The whole operation took about 30 minutes (this is based on the time for Soyuz 31 which undocked at 1153 and redocked at 1221:29 on 7 September 1978). After floating back into the station the Dneipers set about tidying up the compartments in readiness for their next visitors who were due to depart the very next day.

The second manned flight of the May/June window saw the first manned flight of the Soyuz T (the "T" stands for Transport) spacecraft. The flight plan envisaged a docking with Salyut, after extensive checks of the spacecraft's systems, by the two man crew who would work for three days with the Dniepers and then return home. This simple plan would cover all the main aspects of the job the new spacecraft was designed to do. The landing was timed to occur under the most favourable landing window constraints possible with daylight left to attempt a search should the cosmonauts land off-target.

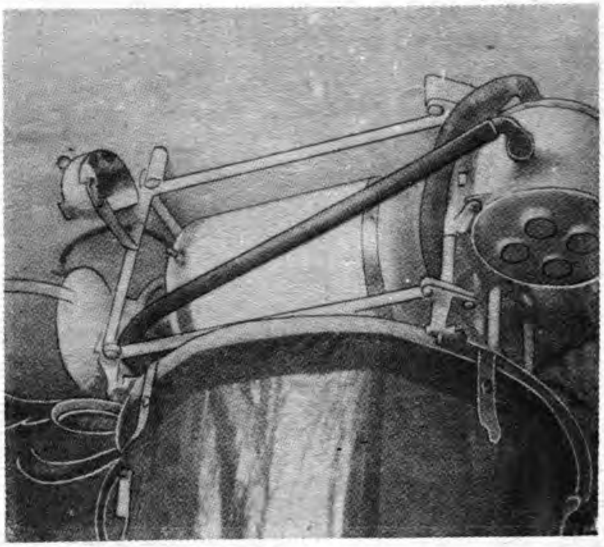
The cosmonauts assigned to be the first to fly a Soyuz T into space were 38 year old Lt-Col Yuri Malyshev (selected in the same group as Kovalenok and Lyakhov in 1967), call sign Jupiter, and Vladimir Aksenov who had, in September 1976, accompanied Valeri Bykovski on the Soyuz 22 flight. In preparation for the flight Malyshev and Aksenov had to study computer programming to operate the Argon ABKK (see part 4 of the Mission Report for a description of Soyuz T).

Early on 5 June the Jupiters were woken and, after medical checks and breakfast, donned their new design 8kg pressure suits, specially developed for Soyuz T. The suits featured, in addition to their lightness, new air supply systems, zip arrangements, improved hinge joints in the elbow, wrist and knee joints, helmets allowing almost peripheral vision and improved dexterity in the gloves (it is claimed that a cosmonaut can pick a single match from a box using the new gloves.)

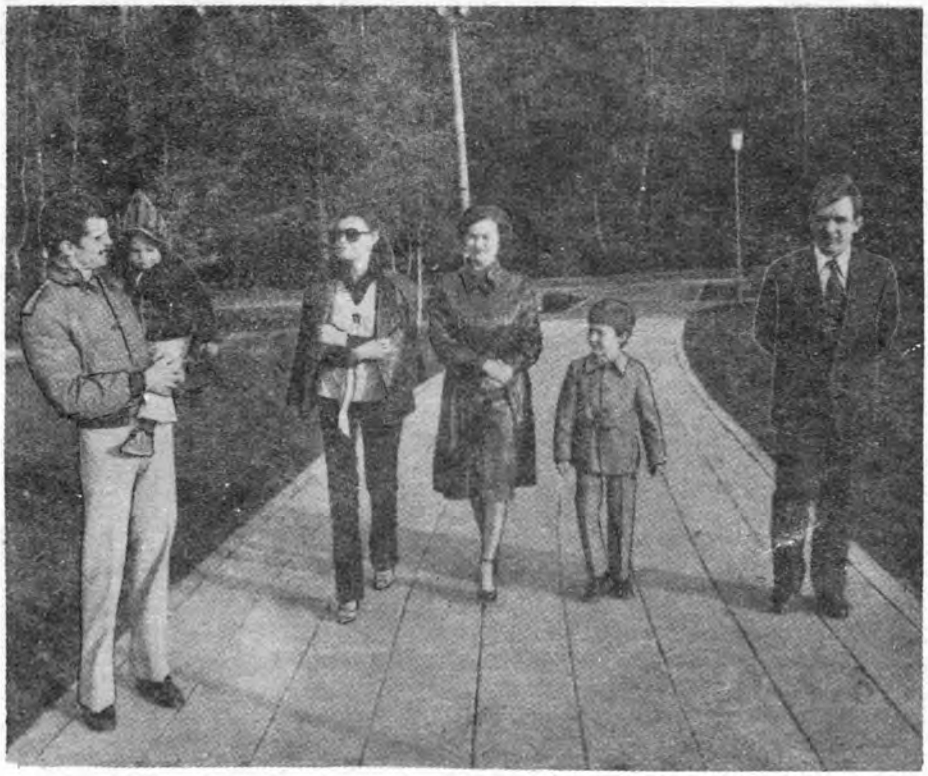
The launch of Soyuz T-2, on a standard A2 carrier rocket, occured at 1419. The only visible modification to the A2 was the introduction of a new, longer launch escape tower. Once in orbit the ABKK assessed the amount of thrust the cosmonauts would have to instruct the ODU engine to make to put the spacecraft into the corrected orbit. After receiving instructions to proceed from the crew the ABKK commanded the ODU, in two stages, to fire. The resulting orbit had a height of 267 x 316 km, period 90.2 minutes. Shortly after those 4th and 5th orbit maneouvres Soyuz T-2 drifted out of the coverage of the tracking stations on the USSR's land mass.

The improved temperature regulation systems of the transport ship allowed the crew to maintain the internal temperature to 20°C. For the first time on a Soviet spacecraft the crew were able to see the internal pressure for themselves on a gauge - it was 787 mm on the mercury column. One US source noted that although improved the Soyuz still provided cosmonauts with very little information and piloting control even comparing the level to that of the Gemini series spacecraft flown in 1965-66.

Following another maneouvre the next morning Soyuz T-2 was approaching Salyut 6. After asking for permission to proceed with the approach the ABKK brought Soyuz T-2 to within 180m of the station at which point, because of an unspecified deviation from the normal operating procedure of the ABKK, Malyshev over-rode the computer and guided the



Cosmonauts' shower of the type used aboard the Salyut 6 space station. Photograph shows the top section which is attached to the 'ceiling'. *Theo Pirard*



Valery Kubasov and his wife Lidia and son with Bertalan Farkas and his wife Aniko and daughter Aida. For biography of cosmonaut Farkas, see page 57. *Novosti Press Agency*

transport ship to a successful docking with the rear docking port at 1558 (6 June). During the operation Malyshev's pulse peaked at 130 beats/min.; Aksenov's peaked at 97. Amid much joviality the Jupiters crossed over into Salyut, some 3 hours after the docking, to be greeted enthusiastically by the Dneipers. Following traditional welcoming toasts (in fruit juice) the Jupiters handed over mail and gifts to the resident crew.

For the next three days the two crews were busy performing experiments and loading Soyuz T-2 with equipment and experiment results. Photography of the Earth and oceans with the MKF-6M camera was accomplished by Aksenov and the Refraction experiment was conducted. Medical tests were performed on the Dniepers showing them to be in excellent health and equipment was prepared for future experiments.

No sooner it seemed than the Jupiters arrived than they had to depart. At about 0925 on 9 June Soyuz T-2 was undocked from Salyut. The Jupiters then commenced to fly the transport ship around Salyut for inspection and photography of the station. On earlier occasions, because of Soyuz's limited propellant, the station had had to turn round so that cosmonauts in the stationary Soyuz could photograph it (for photography of this type of manoeuvre see *Soviet Union*, January 1980, pp 12-13). The manoeuvre by Soyuz T-2 is attributable to the ODU fuel supply system.

In another variation to the earlier Soyuz versions Soyuz T-2 jettisonned the Orbital Compartment before the retro burn rather than after, this saves about 10% of fuel used normally for retrofire. Some minutes before 1200 the ODU was activated to bring Soyuz T-2 out of orbit and several minutes later the engine section and descent cabin separated. During the re-entry, because of the heat, the windows of the descent cabin became covered in thick black soot, as happens on all re-entries. Once the module was being braked by parachutes outer panes on the windows were cast off leaving inner panes which were untouched by the heat and soot, affording the cosmonauts a clear view of the flat steppes of Kazakhstan where, at about 1240 ($\pm$5 mins), Soyuz T-2 landed in a cloud of dust blown up by the enlarged retro-rockets at the base of the cabin. The Jupiters were soon outside meeting reporters and signing their names on the outside of the cabin, as custom dictates. Medical checks showed them to be in good health.

In accordance with tradition the Orions were flown back, after their debriefing and recovery at Baikonur, to Moscow to receive their awards. The duo was greeted first at Zvyodny Gorodok's Chkalovskaya Airport by their families and comrades. Later that day (10 June) the cosmonauts were given their awards by Leonid Brezhnev in a reception at the Kremlin. Following a press conference the cosmonauts flew to Budapest where, on 17 June, they met Janos Kader the Hungarian State and Party Leader.

In a press conference Kubasov made a statement about the western implication that military objectives were a part of the flight. "We have published the entire programme of our scientific research. This shows that all the programmes we carried out served peaceful scientific purposes only," Kubasov stressed. The cosmonauts, along with Bela Magyari and FCC director Aleksei Yeliseyev then embarked on a several day tour of Hungary.

Following the departure of Soyuz T-2 the Dniepers settled down to their daily routine of exercises, medicals and experiments. During the rest of June they took advantage of the long summer nights and reasonable weather over the USSR to conduct extensive visual and photographic observations of the Earth and oceans and in particular sites in the USSR, Hungary and the other socialist countries. They paid special attention to monitoring the growing season of cereals such as bread grain, attempting to forecast the productivity of pasture land and assessing water reserves in the Pamir and Tien-Shan mountain ranges.

The Dniepers also conducted observations with the BST-1M of beta Centauri; obtained gamma quanta readings with the Elena-F detector and conducted smelting experiments (see part 3 of the Mission Report for the experiment descriptions of the above). Generally the cosmonauts worked efficiently and ahead of the flight plan with their productivity increasing steadily as the flight progressed. While they worked the two men detailed equipment and supplies they needed to FCC who were scheduling the cargo to be carried on the next Progress ferry ship due to be launched at the end of June.

[To be continued]

SPACE REPORT

FIRST SPACELAB EXPERIMENTS

Thirty-seven experiments have been selected by the European Space Agency and NASA for the initial flight of Spacelab, writes Gordon L. Harris.

Date of the launch is uncertain because of Shuttle delays. Currently NASA expects the reusable vehicle can accommodate Spacelab in late 1982.

The approved experiments represent five categories of scientific and commercial interest: atmospheric physics and Earth observations, space plasma physics, material sciences and technology, astronomy and solar physics and the life sciences.

ESA will sponsor 24 of the experiments and NASA 13. Each agency will accommodate 3,062lb. (1392 kg) of experiment equipment. Three NASA-sponsored experiments and a major ESA facility were deferred for assignment to future Spacelab missions. Mass was the major limiting factor.

Five payload specialists, two Americans and three Europeans, are training for the first Spacelab. Two, one American, one European, will be selected for the flight. The others will operate Earth-based equipment related to the flight experiments.

ESA-sponsored experiments and principal investigators include:

Dr. M. Ackerman, Institut d'Aeronomie Spatiale de Belgique, grille spectrometer.

Dr. M. Herse, Service de Aeronomie du CNRS, France, waves in the OH emissive layers.

Dr. G. Thuillier, Service d'Aeronomie du CNRS, France, measurement of solar spectrum from 170 to 3200 hanometers.

Dr. J-L. Bertaux, Service d'Aeronomie du CNRS, France, Lyman Alpha Study of hydrogen and deuterium.

Dr. Klaus Wilhelm, Max Planck Institut fur Aeronomie, Germany, low energy electron flux and its reaction to active experimentation.

Dr. C. Geghin, CRPE/CNET/CNRS, France, phenomena induced by charged particle beams.

Dr. D. Crommelynck, Institut Royal Meteorologique, Belgium, solar constant measurement.

Prof. G. Courtes, Laboratoire d'Astronomie Spatiale, France, very wide field camera.

Dr. R.D. Andresen, ESA/ESTEC/SSD, The Netherlands, spectroscopy in X-ray astronomy.

Dr. R. Beaujean, Institut fur Reine und Angewandte Kernphysik der Universitat Kiel, Germany, isotopic stack measurement of heavy cosmic ray isotopes.

Dr. Helen Ross, University of Scotland, mass discrimation during weightlessness.

Dr. K. Kirsch, Physiologisches Institut der Freien Universitat Berlin, measurement of intrathoraxic venous pressure via a peripheral vein. And collection of blood samples for determination of antidiuretic hormone, aldosterone and other hormones.

Prof. Dr. H. Bucker, DFVLR Institut fur Flugmedizin, Germany, advanced biostack experiment.

Prof. Aristide Scano, University of Rome, ballistocardiographic research in weightlessness.

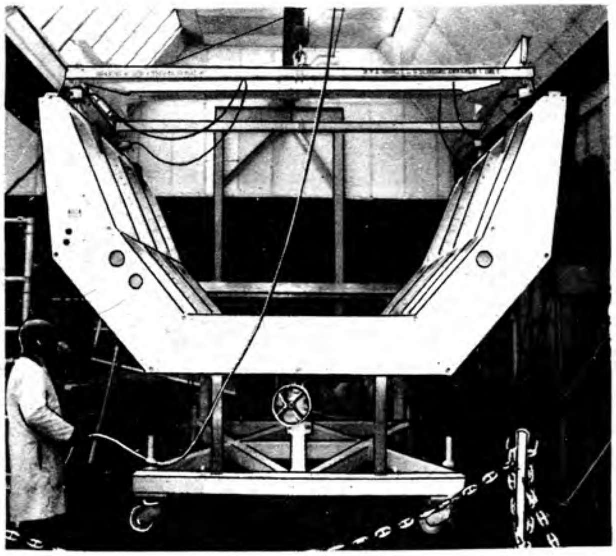
Dr. G. Horneck, DFVLR Institut fur Flugmedizin, micro-organisms and biomolecules in space environment.

Dr. H.L. Green, Clinical Research Centre, Middlesex, personal miniature electro-physiological tape recorder.

Dr. Augusto Cogoli, Eldgenossische Technische Hochschule, Switzerland, effect of weightlessness on lymphocyte proliferation.

Deutsche Forschungs und Versuchsanstalt fur Luft und Raumfahrt, Germany, metric camera; also microwave remote sensing experiment and material science double rack facility.

Prof. Dr. R. von Baumgarten, Johannes Gutenberg Universitat, effect of rectilinear accelerations, optokinetics and caloric stimulations on human vestibular reactions and sensations in space.



Dr. C. Belouet, Laboratoire d'Electronique et de Physique Applique, France, mercury iodide growth

Prof. J.F. Nielsen, Technical University of Denmark and Prof. A. Authier, Universite Pierre et Marie Curie, France, organic crystal growth/growth of manganese carbonate.

The NASA sponsored list:

Dr. Marsha Torr, University of Michigan, an imaging spectrometric observatory.

Prof. Tatsuzo Obayashi, University of Tokyo, space experiments with particle accelerator.

Dr. Stephen Mende, Lockheed Research Laboratory, atmospheric emission photometric imaging.

Prof. Stuart Bowyer, University of California, far UV observations using the Faust instrument.

Prof. Eugene Benton, University of San Francisco, HZE particle dosimetry.

Dr. Frank Sulzman, Harvard Medical School, characteristics of persisting Circadian rhythms.

Dr. Richard Willson, Jet Propulsion Laboratory, active cavity radiometer solar irradiance monitor.

Dr. Raymond Gause and Ann Whitaker, NASA and Dr. Coda Pan, Shaker Research Corp., tribiological experiments in zero gravity.

Prof. Allan Brown, University of Pennsylvania, nutation of helianthus annuss.

Prof. Laurence Young, Massachusetts Institute of Technology, vestibular experiment.

Dr. Carolyn Leach, Johnson Space Center, influence of space flight on erythrokinetics in man.

Dr. Millard Reschke, Johnson Space Center, vestibulo spinal reflex mechanisms.

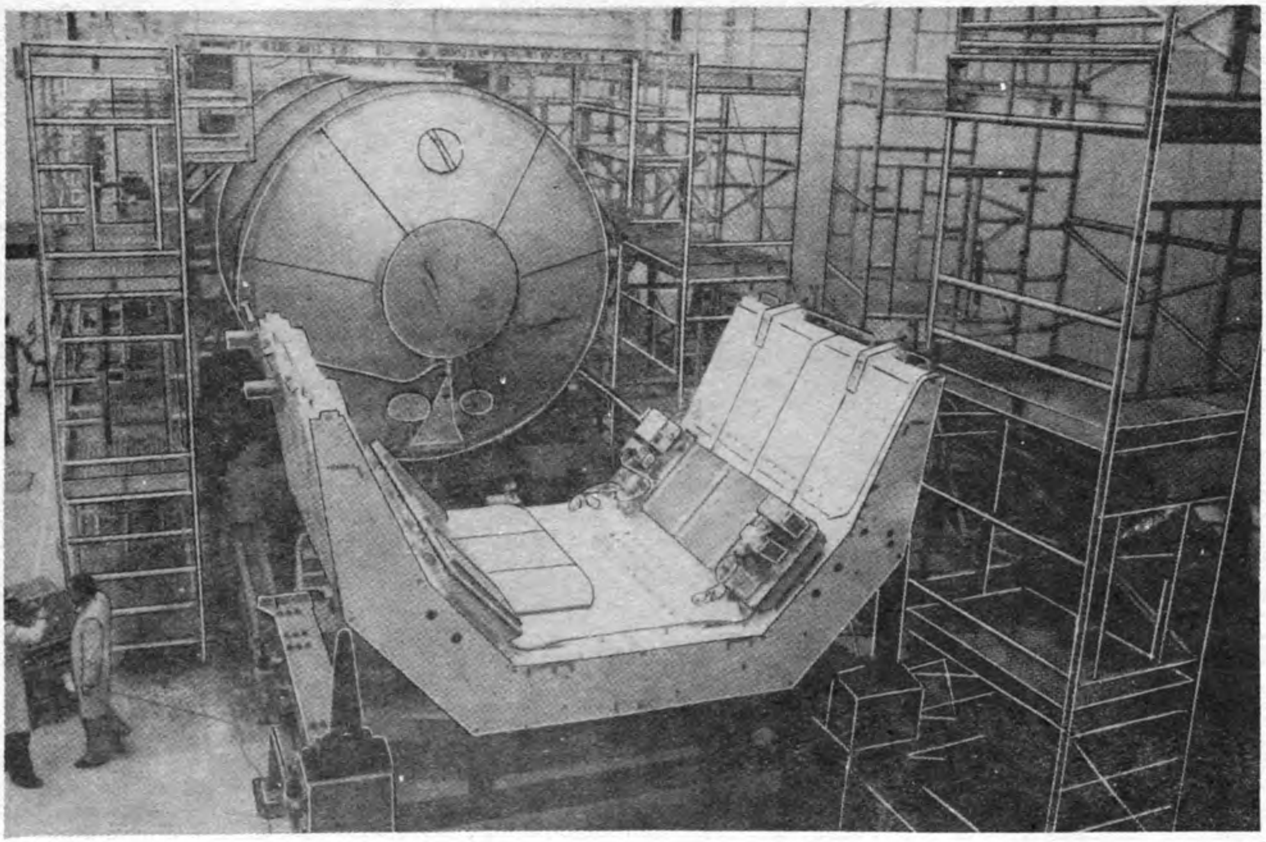
Prof. Edward Voss, University of Illionois, effects of prolonged weightlessness.

SECOND SPACELAB

NASA has signed a $183,960,000 contract with the European Space Agency for a second Spacelab to be delivered in 1984, writes G.L. Harris.

The ERNO facility in Bremen, prime contractor to ESA for Spacelab 1, will be the manufacturer. Twenty-six sub-contractors in Germany, France, United Kingdom, Italy, Spain, Belgium, The Netherlands, Switzerland, Austria, Denmark and the United States will produce components and subassemblies.

ESA is completing Spacelab 1 in time for an early opera-



Spacelab assembly at the ERNO integration hall in Bremen; left a prototype space pallet being prepared at British Aerospace, Hatfield.
ERNO and BAe

tional flight of the Space Shuttle, now expected in 1982. ESA has invested about $850,000,000 in the first reusable scientific laboratory. In return for ESA's contribution of the initial unit, the United States agreed to buy a second and more if needed in the future.

Sized for Shuttle's large payload bay, Spacelab will be carried on missions lasting seven to 30 days. It can be adapted to specific experiments and will provide a shirt-sleeve environment similar to a jetliner for male and female experimenters. One to four payload specialists can be accommodated.

Spacelab operations in flight will be managed by NASA's centre in Houston, Texas while the Huntsville, Alabama centre provides technical support in the development phase and administers the NASA-ESA contract.

COST OF SHUTTLE DELAYS

NASA's technical problems with its reusable shuttle, running two years behind schedule, have prompted government and commercial users to pay higher prices for conventional launch vehicles, writes Gordon L. Harris.

The agency announced in late August that it will launch 22 Delta and Atlas Centaur vehicles from September 1980 until December, 1982 to boost customers' spacecraft into geostationary orbits.

Nineteen of the missions involve communications satellites, two of which will be supplied by the U.S. Navy as part of a worldwide system. Three others are environmental-weather spacecraft flown for the National Oceanic and Atmospheric Administration.

NASA did not list any of its own spacecraft in the schedule. It includes four launches in the closing months of 1980, 10 in 1981 and eight in 1982 when the shuttle is supposed to begin carrying cargo (September 1982).

Thirteen Deltas, built and launched by McDonnell Douglas, and nine Atlas Centaurs, the more powerful General Dynamics booster, will handle the customer-sponsored launches in the next two years.

Since NASA continues to quote $11 million as the base price for transporting a satellite into low Earth orbit, users must pay a premium for expendable rockets: $27 million for a Delta, $36 million for a Centaur.

Those figures do not tell the whole story. Shuttles will operate some 200 miles above Earth. Hence another power stage must be available to boost a satellite from that altitude to the desired geostationary position some 22,300 miles above the Earth. Upper stages for that purpose are in development.

Meanwhile an uprated Delta can deliver approximately one ton while Centaur can send two tons to a geostationary orbit.

NASA's published manifests disclosed that the International Satellite Consortium of 102 nations will be the major user in 1980-82 with six spacecraft boosted by Atlas Centaurs. Canada plans two Telesats in 1982 when India will launch its first combination weather-and-communications spacecraft.

Other users include Satellite Business Systems, a newcomer, two missions in 1980 and 1981; Communications Satellite Corporation, one in 1981; RCA, two in 1981 and one in 1982; AT&T, one in 1982; and Hughes, one in 1982.

New NASA Launch Schedule

Sponsor	Vehicle	Date*
1980		
GOES-D (NOAA)	Delta	Sep 9
SBS-A (Sat.Bus:Systems)	Delta	Oct 23
FLTSATCOM (Navy)	Atlas Centaur	Oct 28
Intelsat V F-2 (Consortium)	Atlas Centaur	Nov 20

1981		
Comstar (Comm.Sat.Corp)	Atlas Centaur	Feb 26
Goes-E (NOAA)	Delta	Mar 12
Intelsat V F-1 (Consortium)	Atlas Centaur	Mar 19
SBS-B (Sat.Bus. Systems)	Delta	Apr 23
FLTSATCOM (Navy)	Atlas Centaur	Jun 2
RCA D(Radio Corp America)	Delta	Jun 18
Intelsat V F-3 (Consortium)	Atlas Centaur	June 25
Intelsat V F-4 (Consortium)	Atlas Centaur	Sep 17
RCA C1	Delta	Oct 29
Intelsat V F-5 (Consortium)	Atlas Centaur	Dec 10
1982		
Westar IV (AT&T)	Delta	Jan 7
INSAT 1-A (India)	Delta	Feb 18
Telesat-E (Canada)	Delta	May 13
Telesat-F (Canada)	Delta	Aug 5
GOES F (NOAA)	Delta	Sep 16
RCA-E (Radio Corp America)	Delta	Oct 28
HCI (Hughes)	Delta	Dec 9
Intelsat VI (Consortium)	Atlas Centaur	2th Quarter

* *Planned (not necessarily actual launch dates).*

MOVING INFORMATION, NOT PEOPLE

In a global environment of energy shortages, telecommunication wili be used increasingly as an alternative to transportation, a world leader in satellite communications has predicted. Speaking at an International Telecommunications Executive Forum in Tarpon Springs, Florida, the Director General of Intelsat, Mr. Santiago Astrain, said that it had always been easier to move information than people.

But, he said, with the emergence of new digital communications technology, the economic attractiveness of electronically moving information would become increasingly irresistible.

"If the application of these techniques could enable the cost of telephone services to be reduced to one-fifth of today's level and, at the same time, allow videotelephone service to be achieved for five times the cost of today's telephone services, there would be a huge jump in demand for both types of services."

Mr. Astrain cited figures compiled by the U.S. National Aeronautics and Space Administration on projected demand for telecommunications within the U.S. by the year 2000. These showed a total requirement for some 20 million long-distance voice channels in operation, 350 long-distance video channels and facilities to handle 35,000 terabits of information a year.

He said that in the international communications sphere Intelsat, which currently carries about two-thirds of the world's international transoceanic communications, had put together its own projections based upon information provided by its Signatories and users around the world.

These predictions showed a traffic growth rate which would result in a requirement for 500,000 voice circuits by 2000, plus a significant number of video and data links.

"However, if, starting in the mid-1980's, there is a tremendous growth in services such as computer networking, electronic mail, digitized voice and videoconferencing, it is possible that our current predictions will prove too conservative," he said.

Mr. Astrain then outlined Intelsat's current plans for dealing with this potential explosion in demand. Intelsat expected to begin launching its new Intelsat 5 satellite network in 1980. This network, which will more than double the capacity of the current system, is expected to cost in the vicinity of $500 million.

Future spacecraft and systems would represent even larger investments, Mr. Astrain said. Intelsat was already planning well beyond the mid-1980's and the Intelsat 5 system.

"At this time we are actively exploring Intelsat 6 designs, optimised to meet the requirements of the mid-to-late 1980's and the early 1990's."

One attractive concept currently under study was the Intelsat 6-B6 design which, in a series of graduated steps, could achieve an ultimate capacity of 41,000 circuits per satellite. This compared with the 6,000 voice-circuit capacity of the Intelsat 4-A satellites in the present global system and the 12,000-circuit capacity of each Intelsat 5.

The 6-B6 concept also offered a great deal of flexibility in dealing with different modes of transmission. But even this satellite would not be able to meet the high volume demands of the digital communications revolution by the mid-to-late 1990's. Three different concepts were now being studied which may be able to deal with this challenge - the space platform, the satellite cluster and the satellite string.

The space platform, a structure in space, would carry not only communications facilities, but equipment for numerous other space applications, such as Earth resources survey and meteorological services.

Such a structure would allow the pooling of basic support systems, including power supply etc., the use of thin pencil beam transmission possibly focussed on individual Earth stations, the in-space switching of signals and the interconnection of the various functions on the platform.

The satellite cluster is a similar concept to the platform but without the rigid structure. Here a number of satellites would be located around one central signalling and switching satellite.

This system, although probably initially cheaper than the platform, would not have the same lifetime nor would it achieve the same efficiency.

The satellite string concept was essentially similar to the cluster but the individual satellites lined up in geosynchronous orbit and interconnected by intersatellite links. The string would have less capacity than the cluster but could be cheaper and more reliable, Mr. Astrain said.

EXPLOITING MICROGRAVITY

Having aroused less interest than hoped for in commercial exploitation of microgravity, NASA has embarked upon a new programme designed to encourage industrial development, writes G.L. Harris.

For the first time the U.S. space agency has signed a joint endeavour pact with private industry for materials processing in the orbital environment. No expenditure is required of NASA.

The McDonnell Douglas Corporation, builders of Delta rockets and Saturn upper stages, and a pharmaceutical firm will finance a research effort to determine the feasibility of separating biologicals by means of continuous-flow electrophoresis.

The process has a high probability of producing substances useful in diagnosis, treatment or prevention of diseases in humans and animals. These substances are not being produced in sufficient quantities or purity in Earth-based laboratories.

This agreement covers three phases. McDonnell Douglas will first establish feasibility through ground-based research and define flight experiments. In Phase II the company will develop an experimental system and NASA will furnish launch and on-orbit operations for two Shuttle missions to test the system's effectiveness in low gravity. For the final phase McDonnell Douglas will use information and data collected in Phases I and II to design and develop a pre-commercial system.

NASA will test this equipment on two more Shuttle flights.

If the experiments confirm the practical value of the system, McDonnell Douglas will then proceed to market the technology and buy space and in-flight support from NASA to process the commercial products.

Among the pharmaceuticals eligible for space processing are proteins, hormones, and cells which may be used to treat hémophilia and anaemia, and a new and vastly improved treatment for diabetics.

The assignment of rights to resulting inventions and data is subject to negotiation. In consideration of high risks the participating company may be afforded process exclusivity to protect its capital investment.

"We believe other firms will eventually become interested," said Lowell Zoller, materials processing chief of NASA's Marshall Space Flight Center. "It's a matter of understanding the effects of gravity on materials and exposing industry to the new dimension space processing can provide for their products."

MOUNT ST. HELENS

Ever since the spectacular 18 May eruption of Mt. St. Helens in Washington State, NASA has been working closely with scientists from universities and other government agencies to assess the impact of the explosive geologic event. Instrument-laden NASA aircraft, balloons and satellites all have contributed important data to scientists' efforts to understand a natural phenomenon rarely observed so close-at-hand. As a result Mt. St. Helens is undoubtedly history's best documented volcanic eruption.

Shortly after the eruption began, a high-flying U-2 aircraft from NASA's Ames Research Center, Mountain View, California, was dispatched to sample the air within 185 km (100 miles) of the volcano. Back on the ground, scientists working with NASA's Aerosol Climatic Effects Program used the data collected on particulate matter to study the potential climatic effects of the ash blown into the upper reaches of the atmosphere by the violent explosion.

Repeated U-2 flights, days after the eruption, continued to track the volcanic dust cloud and to photograph the devastation wrought upon the mountain by its self-destructive blast.

Another aircraft, a WB-57F on loan to NASA's Johnson Space Center, Houston, and the Department of Energy for a different project, sampled particulate concentrations above Kansas, Nebraska, Wyoming and Denver, Colorado.

Meanwhile, a team at NASA's Langley Research Center, Hampton, Virginia, used a 1.2-metre (48in.) laser radar (known as "lidar" - for light detection and ranging) on several occasions to probe the skies over the lower Virginia peninsula for traces of volcanic dust.

Later, mounted aboard a P-3A Orion aircraft from NASA's Wallops Flight Center, Wallops Island, Virginia, the lidar detected dust in the stratosphere as the plane flew as far west as Chicago and St. Louis before returning to Virginia.

A subsequent flight took the plane north over New York and Ontario and west to Illinois.

The day of the initial eruption, a member of NASA's Stratospheric Aerosol and Gas Experiment (SAGE) team launched a package of instruments aboard a balloon in Wyoming. Designed to penetrate and measure the dust plume, the balloon's instruments detected stratospheric dust concentrations some 400 to 1,600 times normal.

The Stratospheric Aerosol and Gas Experiment satellite, launched in 1979, was also used to track the dust clouds, as it had for two previous volcanic eruptions, including that of La Soufriere in the Caribbean. Beginning three days after the 18 May Mt. St. Helens eruption, and continuing for eight days, the satellite mapped the stratospheric dust cloud before the satellite's orbit took it out of range.

Complementing these studies as the satellite passed over the Atlantic Ocean, and later as it passed over North Carolina, was an underflight by the Orion P-3A from Wallops Flight Center. A similar underflight was conducted using a Super Loki sounding rocket launched from Wallops. These underflights provided scientists with simultaneous data readings from "above" and "below" the atmosphere.

In the past, large volcanic eruptions have been responsible for climatic changes.

The data collected by NASA instruments studying the dissipating dust cloud will allow scientists to determine what effect, if any, the Mt. St. Helens eruptions might have on local, regional and world climate patterns.

By late June, scientists at the Langley Center believed that Mt. St. Helens had the potential to increase the total amount of global stratospheric aerosols by as much as 50%. But, add the scientists, there are no indications that Mt. St. Helens will trigger any adverse climate change.

From mid-July to early August, a team from the Johnson Center and the Los Alamos Scientific Laboratories flew the WB-57F aircraft as far south as the equator and as far north as 75 degrees north latitude to take another look at how the particles of volcanic dust are dispersing.

The SAGE satellite was back in position over the Northern Hemisphere in early August when further underflights of the P-3A aircraft were made.

Langley's Aerosol Measurements Research Branch was planning to bring scientists together in November for an intensive seminar to discuss the findings from the satellite and other instruments studying the dust cloud around the world.

NASA will continue its efforts to collect data as long as Mt. St. Helens continues to spew ash and dust into the atmosphere.

FUTURE TRANSPORTATION NEEDS

The Boeing Aerospace Company has been selected to assist NASA in a study of future space transportation requirements.

In the post-1990 time period, with NASA's Shuttle-based Space Transportation System fully operational, user requirements may outgrow the capacity of presently planned orbital transfer vehicles to move large structures and satellites from low Earth orbit up to geostationary orbit, 23,000 miles out in space, and to carry scientific probes to other planets.

In preliminary planning for this future need, the Marshall Space Flight Center has studied several possible candidate advanced propulsion systems including rocket engines heated by solar concentrators, lasers, and advanced electric propulsion.

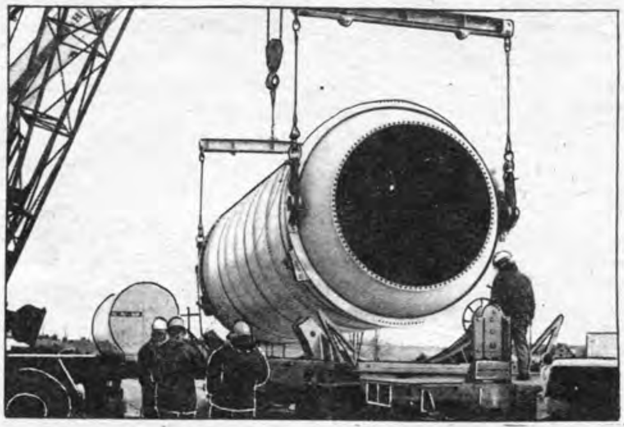
These and other systems studies are now ready for analysis and comparison to determine which concepts are the most likely candidates for further study and possible development to meet space transportation needs 10 to 20 years from now.

To conduct this analysis and comparison, the Marshall Center has selected the Boeing company for a 12 month contract valued at about $200,000.

LAST OF THE VON BRAUN MEN

"All the projects were alike in that there were opportunities for new work and new challenges to make successes." Those are the words of Gustav A. Kroll, the last member of the original "von Braun team" to leave NASA's Marshall Space Flight Center, Huntsville, Alabama. He was speaking of the projects

Gustav A. Kroll, the last memeber of the von Braun team at the Marshall Space Flight Center, who has now retired. He came from Germany in 1945 in "Operation Paperclip" and initially worked at Ft. Bliss, Texas. *NASA*



Two segments of a Space Shuttle Solid Rocket Booster (SRB) being loaded onto special rail cars for shipment to the George C. Marshall Space Flight Center. They were subsequently used in mated ground vibration tests with the complete Space Shuttle 'Enterprise' test vehicle. *NASA*

on which he has worked since he came to Huntsville in 1950. The head of the Structures Division of Structures and Propulsion Laboratory, Kroll retired just six weeks short of having 35 years of government service.

Kroll arrived in the United States in 1945 in "Operation Paperclip" and worked at Ft. Bliss, Texas, with the 118-member von Braun team. They were transferred to Huntsville in 1950, and Kroll became an American citizen in 1954.

He has worked in structures throughout his career. "I have worked on every one of Marshall's projects - Redstone, Jupiter, Saturn, Shuttle - all of them," he said. "In looking back at all of these projects, there are no favourites, but the highlight would have to be the Saturn V flight and landing on the Moon."

Kroll received the NASA Exceptional Service Medal on 4 November 1976, for "exceptional scientific achievement in guiding the overall structural design of the Solid Rocket Boosters which culminated in a unique combination of weight savings, low-cost manufacturing and high reliability for reusable structures."

Two Solid Rocket Boosters will be used during the first two minutes of flight on each Space Shuttle launch. They will be recovered from the ocean and refurbished for repeated use.

WORKING INSIDE A ROCKET MOTOR

What Charles M. Lewis did is hardly the activity for a person with claustrophobia - or for a nervous individual. Lewis, an engineer at the Systems Analysis and Integration Laboratory at NASA's Marshall Space Flight Center, Huntsville, Alabama, let several men lower him into the bore of an inert forward segment of a Space Shuttle Solid Rocket Booster in a test at the Kennedy Space Center recently.

It all came about when the question arose, "How could a man get inside a solid rocket motor and do useful work if repairs to the propellant were necessary?"

The trick was to lower a man into the 22-in-diameter bore and down 12 ft to where the "tube" is 57 inches in diameter. It was here that Lewis was to "work".

The first step was to find an existing and available device to hold him. A hang glider harness looked as if it might work - and it did. "Super comfortable," was Lewis' description.

The worker would have to remain suspended inside the core while he worked, possibly for two or three hours. Since some hang glider pilots stay airborne three or four hours, their harnesses must be comfortable.

The harness proved to be compact enough for Lewis to slip through the small opening but comfortable enough to be worn for extended periods. It was also easily adjustable, allowing him to pivot himself toward the propellant surface. He was in the segment about 45 minutes.

"Hanging in the middle of a 57-inch-diameter tube, a man can't reach the work area easily. By pivoting and hanging at an angle in the harness, he can reach the wall with his hands and brace himself with his feet against the opposite wall," Lewis explained.

"Besides testing the harness for mobility," Lewis added, "we wanted to know what else was needed - such as a respirator, tools and intercom. The tests told us what we would need."

Why would it be necessary to enter a solid rocket motor? According to E.G. Eudy, it is a contingency procedure. Eudy is head of the Solid Rocket Motor Office in the Office of Associate Director for Engineering, Science and Engineering Directorate at MSFC.

Motor segments are inspected carefully after the poured propellant has cured and the mandel has been removed at the Thiokol Corporation plant, he said, and if any cracks are found, repairs are made.

After the segments have been delivered to KSC, another inspection is performed prior to stacking. As a precaution, the two motors for the first Space Shuttle mission, now assembled at KSC, will be inspected using a television and a 35mm camera on a boom extended into the bore.

Eudy said he does not expect inspectors to find flaws after stacking, but if cracks are detected a contingency procedure for repairs would avoid destacking the motor.

Open to Members of the Society both in the U.K. and U.S.A.

SOLAR ECLIPSE, JULY 31st 1981

The Southern California Branch is planning a group expedition to view the solar eclipse on 31st July 1981. A tour of about 3 weeks in duration is envisaged, starting from Los Angeles and with a stopover in London, where U.K. participants will be able to join the Group.

From the U.K. the Itinerary will include the flight from London - Peking with seven days spent in China visiting the Great Wall, Ming Tombs, etc., a rail link for two days in Ulan Bator Mongolia; two days in Irkutsk, Eastern Siberia and three nights (July 29th-31st) in Brask, from where the eclipse will be viewed. The return will be via Brask-Moscow-London.

Arrangements are in the hands of Mr. R.V. Frampton, Mailstop 264-519, Jet Propulsion Laboratory, Pasadena, California 91103, U.S.A.

Members interested should contact Mr. Frampton for inclusion in the preliminary list of participants and/or further details. The total cost from London will be around £3,000.

LIBRARY PROGRESS REPORT

Seeking Books

Developing a specialised Space Library for the Society has proved an uphill task. Originally it was envisaged that books would roll in from all quarters, but this proved to be far from the case. Those members who *did* supply items have contributed extremely well, but the problem remains one of numbers - there were too few of them. Consequently, many of the Library shelves have remained empty and the opening of the Library delayed because the quantity of material was far too small to prove viable.

This was borne out, repeatedly, by double checking against "needs and requirements." Invariably, it was found that the material wanted simply wasn't there. Further checks were made against new and secondhand book lists, bibliographies, etc., but these not only confirmed serious and wide omissions but induced, alternately, bouts of an enormous inferiority complex and green-eyed envy - from those trying to create a Library from nothing.

To help plug the gaps, individual letters were sent to members who had shown themselves willing to help in the past, and to known or suspected authors, soliciting books for the Library by way of gift even though it was known that authors, contrary to popular belief, do not secure books from their publishers free of charge but actually have to pay for them, *albeit* at trade rates.

This is not to say that the Society's Library doesn't possess *any* books. In fact, it already owns an extremely valuable, partly irreplaceable, collection - and one which grows weekly, even though new additions, when placed on the shelves, seem to disappear into a black hole, leaving the overall appearance of a Library with few books completely unchanged.

And now to a few statistics: We have collected together, so far 1,500 books and 2,400 Reports, quite a tidy total though it is frustrating to be aware of many books and reports we *ought* to have, yet be powerless to obtain them. All these items have been secured for the Society without any expense to members.

Our immediate problem is to try to fill the gaps. Much historical and semi-historical material is no longer available to us: indeed, many reports current only a few years ago cannot be obtained now. Of those we might be able to buy, the cost, at an average of about £5 or £6 apiece, would work out, for the total we need, to between £15,000 -£20,000.

There is no chance that we are going to find this sort of money, certainly not ~~with~~ more immediate problems to hand, such as to finish paying for our new building, as well as coping with inflation if our publications programme is to be maintained. It seems doubtful if any money *at all* will be available for Library costs!

So we need to revert, once more, to a hard slog supported by many personal and semi-personal appeals. These have stood us in good stead in the past and may yield even more if we redouble our efforts. Should readers have material they would like to give, mainly specialised books and reports on Astronomy and Space (though other items might be equally acceptable), please do let us know. Write to the Executive Scretary in the first instance, detailing what you wish to offer, to make sure that it is what we need and that we don't have it already.

Library Stacks

Each Library stack ("bookcase") has been given its own identifying number, with individual bays marked from "a" to "g". Bookcases also have large headings on the top defining the general nature of the contents plus smaller sub-headings for individual shelves.

It hasn't proved practicable, as yet, to key up each shelf number and letter to each index card, for, as the Library grows, the books and reports will have to be rearranged again, perhaps several times.

Cataloguing and Indexing

Material coming into the Library is classified and labelled first, then entered in one of the registers and index cards made out. Much of this work has fallen on Mrs. Arthur, a member of our staff. Members of the Library Committee have also given many hundreds of hours to register items.

The decision to use the NASA filing system has generally turned out to be satisfactory, though we sometimes find that the system is not appropriate to our requirements. For example, it is rather weak on astronomical terms, so subject headings had to be invented in the same style as the NASA system.

Practically all of the Library stock we have on hand has now been indexed. There are twelve drawers of index cards, housed in a separate cabinet, to help locate particular items, listed as follows:-

Top Row

Four boxes of alphabetical subject indexes (books and reports, i.e. all material combined). At the end of the last box is a short list of periodicals intended to be held permanently. Next is the Book Author Index, and lastly a drawer called the "Authority File," which is really a cross-reference index suggesting other possible headings for particular topics.

Lower Row

The first three drawers are for NASA, ESA and similar reports in numerical order, for use where the report number alone is known. Next is one drawer listing Sundry Reports, i.e. from the RAE, US Congress, etc. though we suffer from severe gaps in our reports both as regards individual sequences and the fact that several whole series of Reports are completely unrepresented. The last two drawers deal with reports again but this time they are listed alphabetically under title, for use where the title alone is known.

It will be clear from all this that an enormous amount of time and effort has gone into the cataloguing work, but this is essential for conducting any form of research study.

Even when full the Library will hold only a small part of the available Space Literature but, hopefully, it will contain that part which is the most essential and definitive.

Periodicals and Pamphlets

It is still too early to create much of a collection of periodicals but our special rack contains a representative collection which is slowly growing.

Pamphlets, too, can form the basis of much valuable study. We have obtained various collections of numbered files which will eventually house these though this will probably be the very last of the Library collection to take shape.

Exhibits

The Library has several small models on display, including one of the 'Mustard" - a project for a large reusable rocket propelled vehicle pre-dating the Shuttle by a decade or more. The original painting on display is "Pegasus," a design for reusing a more orthodox rocket.

A display case, kindly donated by Mr. Patrick Ladd, a member of the Society, will give the opportunity for displaying small artifact collections later on and, to complete, if funds or a generous member can be found, another display case will be added to feature further models.

Classic Works

Unlike most of the larger professional Libraries, the Society

has not been enriched or endowed with collections of classic works or manuscripts, so it has no "treasures" of this sort. Hopefully, a member or two will turn up first editions of ancient vintage one day and press them on us if he does not immediately succumb to the high prices such items seem to fetch nowadays.

Until then, we will have to be content with remaining purely envious!

Using the Library
Generally, Reports have been kept separate from Books. In the case of the books, both reference works and books which may be borrowed, if on the same subject, have been placed together. Reference books are those which, by reason of value or rarity cannot be allowed to leave the Library. Each is marked with a large red spot on the spine and, as in added precaution, clearly stamped inside "For Reference Only."

Books for Loan have pockets containing a record car at the back. This will be marked by the Librarian when recording loans.

Opening the Library
Initially, the Library will be open on the same dates selected for Lectures and Film Shows held at HLQ. This will undoubtedly prove much more convenient to members. Announcements about opening dates and times will be carried, from time to time, in both *JBIS* and *Spaceflight.*

The Library Committee will keep a close watch to see how these arrangements work out in practice and to review them from time to time, subsequently.

Intending borrowers should obtain a copy of the Library Regulations which detail the terms under which books are lent. It will be necessary for an application form (obtainable from the Executive Secretary on request enclosing a stamped addressed envelope) to be completed. The cost of a Borrower's ticket will be £1.00 p.a., together with a deposit of £10.00 which will be refundable, normally on the expiry or surrender of the ticket.

Library Regulations
The purpose of the Society Library is *not* to duplicate other sources of information, still less to compete with local public libraries. Its aim is to provide members with facilities for research and reference not readily available elsewhere.

Every member who wishes to use the Library will be sent a copy of the Library Regulations, which he must undertake to observe. Basically, these are aimed at regulating loans and ensuring that the Society's property is fully protected and returned in good order by the dates stipulated, as well as ensuring that the Library is kept comfortable for those wishing to use it besides adequately observing fire regulations.

'The Justification of Space Project Proposals'
On 23 April 1980, Prof. G.V. Groves presided over a meeting in the Golovine Conference Room, Society HQ, at which David Andrews described the formal procedure he has developed, based on the natural design process.

David Andrews explained that, as a consultant in project management, he had participated in formal reviews of the design of the propulsion systems of Ariane, and thereby had to look at design from a new angle. This experience brought home to him that, as seen from a design audit, the logic of design is linear and continuous, whereas, as seen from the inception of a design task, it appears as a forest of decision trees leading nowhere in particular. By tracing the logic back from the point of audit in particular cases, he had been able to identify the internal structure of the design process, and was surprised to find that no one had done that before.

By creating an appropriate system of documentation to match the identified logic, a powerful procedure has been developed for the management of design. This permits a designer to take into account a wider range of constraints than can be properly organised by a single human mind, permits the best programme of study to be discovered so that there is a minimum of reiteration, and permits all who have relevant knowledge to contribute to the design process at the appropriate time without interfering with the conceptual tasks.

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INTELSAT MOVES AHEAD

A series of decisions taken by Intelsat will determine the pattern of development of the global international satellite communication system for the 1980's.

Intelsat is the 104 member nation organization which owns and operates the satellite system used by 143 countries and territories around the world for international communications and by 16 countries for domestic communications.

Meeting in Bogota, Colombia, the Intelsat Board of Governors decided:

- To proceed with the purchase of some key items required for the manufacture of a ninth Intelsat V series satellite.
- To order three additional Atlas Centaur launch vehicles, with improved performance capability, from the U.S. National Aeronautics and Space Administration (NASA).
- To procure two more European Ariane launch vehicles from the European Space Agency.
- To begin definition of specifications for an improved Intelsat V satellite - to be known as the Intelsat V-A - as well as for a very high capacity satellite, Intelsat VI.

The decisions involve a total expenditure of more than $230 million.

Intelsat's Deputy Director General (Operations & Development), Mr. William Wood, described the Bogota meeting as one of the most significant in Intelsat's history.

He said decisions taken there set the parameters for international satellite communications until the end of the 1980's.

The Intelsat decision to authorize the manufacturer, Ford Aerospace Communications Corporation, to procure long lead-time items required for the production of a ninth Intelsat V would enable this satellite to be available, if necessary, to cater for growing domestic and international communications requirements in the 1982-84 timeframe.

The first Intelsat V satellite is currently scheduled for launch late this year.

The Intelsat V-A satellites, each with a projected capacity of about 14,000 simultaneous telephone calls (as against 12,000 for Intelsat V) and two television channels, would handle additional demand for communications from 1984 onwards.

From 1986 still larger satellites - Intelsat VI - will be needed to cope with growing demand.

Intelsat VI, which will be designed for launch aboard the Space Shuttle (STS) or the Ariane 4 vehicle, will have a capacity of more than 40,000 telephone calls plus two television channels.

The additional Atlas Centaur and Ariane vehicles will be used to launch the latter Intelsat V satellites and some Intelsat V-A's.

EXPERIMENTS OF OPPORTUNITY FOR THE SHUTTLE

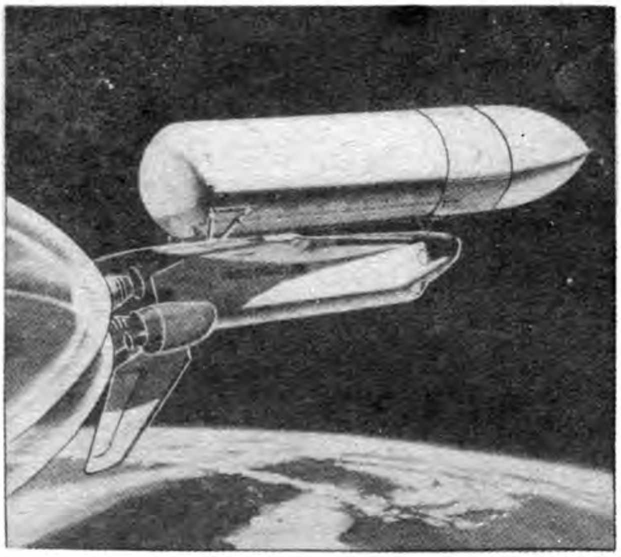
by Dave Dooling

Introduction

The advent of a reusable space transportation system operating on a regular basis with retrievable payloads will offer scientists a number of opportunities not available with expendable spacecraft. Many of these will become apparent only once the Space Shuttle is flying. One coming onto the scene - which was not apparent when the Shuttle was started in 1971 - is adaptation of sounding rocket payloads to flight as temporary satellites.

Although the large, expensive Shuttle does not at first seem to be a competitor for small science payloads, it can, in fact, offer order of magnitude reductions in cost and increases in data. In other words, more data-per-dollar.

As will be shown later, flight of an X-ray astronomy instrument in an Aerobee sounding rocket costs $300,000 versus $1.53 million for the same payload (modified) aboard the Space Shuttle. However, because sounding rockets offer only a few minutes of observing time at best and the Shuttle offers 24 hours at least, almost 100 times as much data can be collected at a cost of 6,500 bits per dollar for the Shuttle ride versus 500 bits per dollar for the Aerobee ride. Put another way, the cost of 24 hours of observing time via repeated Aerobee flights would be $86.4 million, almost three times the basic cost of a dedicated Shuttle mission.



With preparations going ahead at the Kennedy Space Center for the maiden flight of Space Shuttle "Columbia" the road is opening to an entirely new range of opportunities for space research. They extend from the launching of major satellites to small "fill-in" payloads of the kind more normally associated with sounding rockets. Picture depicts the Shuttle Orbiter heading for orbit prior to casting off the External Tank. *NASA*

Experiment of Opportunity Payloads

To take advantage of this potential, NASA is planning the Experiment of Opportunity Payload, or EOP, based on a U.S. Naval Research Laboratory proposal known as Small Payload Ejection and Recovery (SPEAR) [2,3].

The reason for proposing SPEAR, according to authors Cruddace, Fritz and Shulman, is to avoid the high cost of integrating payloads into the Shuttle.

"These interfaces, controlling not merely mechanical, electrical and thermal connections to the payload, but also such matters as mission operations, contractor operations, quality assurance, data handling, and so on, can be very time-consuming and drive costs up remorselessly. We have experienced this often in our own field, space research, when instruments proven in sounding-rocket flights were adapted for satellite missions at a cost exceeding the original cost by more than an order of magnitude.

"Consequently, in the cost of preparing payloads (for Shuttle) we see a serious problem, not just for space scientists, but also for other 'low budget' space users: maintaining a broad base of participation in Shuttle operations."

This concept struck a receptive chord at NASA where plans are to fly SPEAR - now called EOP - aboard an early Shuttle mission, perhaps the fourth flight test. According to Jon R. Busse, [1,9] Shuttle and rocket payloads manager at Goddard Space Flight Center, the first EOP will be a 454-kg package carrying an NRL X-ray experiment that has flown four times aboard Aerobee rockets. So strong is NASA's interest in phasing sounding rockets into Shuttle, he said, that the formerly separate rocket and Shuttle offices were merged in 1979.

EOP "provides a means for flying existing sounding rocket payloads aboard the Space Shuttle by developing small experiment carriers which become Orbiter sub-satellites and are later retrieved and reused [9]." Ideally, Busse said, EOP will provide the sort of quick-reaction development cycle dictated by new celestial events or by the research cycle of a doctoral candidate.

At face value, it would seem an easy matter to put sounding rocket payloads aboard the Shuttle. After all, sounding rockets have been used extensively as test beds for instruments that later flew aboard satellites. Several Spacelab instruments themselves are adapted from sounding rocket or balloon hardware. And, the fact that rocket payloads operate in space would seem to make them readily suited to Shuttle flights.

But the one thing that the experimenter wants more of - time - is the one thing that immediately starts to drive up the cost of switching payloads from rocket to Shuttle. First, more time means more data. A 24-hour flight will operate 288 times longer than a 5-minute flight. Extra time means more electrical power to operate all systems and more control gas. The craft is also exposed to space longer, meaning it must now cope with extremes of temperature rather than making a brief dash somewhat like a finger through a candle's flame.

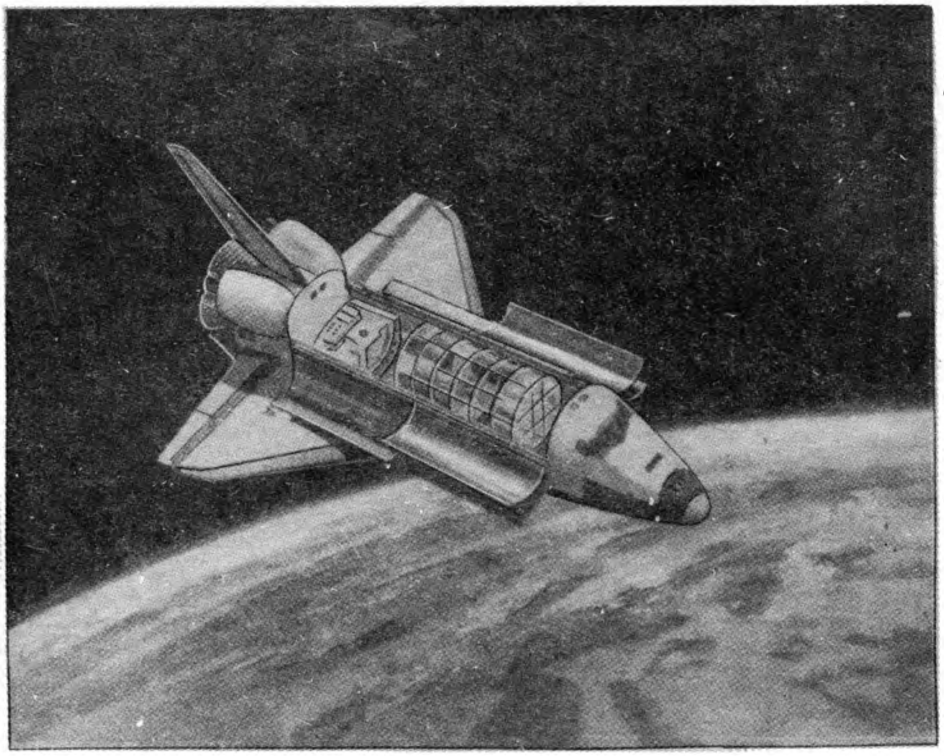
EOP Project: Objectives

The EOP project will, according to Busse:

- Build on existing sounding rocket base using experienced personnel, proven hardware, and minimum documentation and testing.
- Have minimum interfaces to other Orbiter systems.
- Be self-contained and require only payload specialist switch-on and -off. This will allow for standby payloads and rapid response to flight opportunities.
- Use sounding rocket and balloon programme support and software, adapted as required. Safety will be emphasised in mechanical systems; pointing systems will be based on STRAP and SPARCS now in use, power will be delivered by silver/zinc batteries, and data will be stored on tape recorders proven aboard high-performance aircraft.

Busse said the programme will handle payload integration much as for sounding rockets, with a complete package being sent to the launch site and only needing placement aboard the Shuttle. While this will entail a higher risk of failure than extensively-checked payloads, it is necessary to maintain rapid turnaround and low-cost.

The prototype EOP will be a box-like structure, 0.75 x 0.75 x 1.5-m and weighing 454-kg. Equipment drawn from the rocket programme will be the experiment, instrumentation, and attitude control. Nosecone, data transmitter, and recovery system will not be used. New equipment will be the tape recorder, larger batteries, more attitude control gas, thermal insulation, and a grappling fixture.



In this artist's impression the Orbiter's cargo bay contains the Long Duration Exposure Facility (LDEF). The LDEF is a reusable, low-cost free-flying structure in which a variety of passive experiments can be mounted to study the effects of their exposure to space over a relatively long period. After orbiting at Shuttle altitude the LDEF can be retrieved and returned to Earth for experiment analysis.
NASA

Data on EOP will be recorded on a Bell 7 Howell MARS 1400 tape recorder. It has 14 tracks, 6 switchable tape speeds, and will store up to 1 million million bits. Existing pulse-code modulators will be used with modifications to provide data somewhat slower than would be done on a rocket flight.

Attitude control will use strap which has been proven on more than 100 flights. It provides 3-axis attitude control, but no maneuvring, with cold nitrogen gas. Pointing accuracy is 1 arc-minute with a gyro drift rate of 0.02-0.1 arc-second/second. Targets will be acquired under the direction of a micro-processor-directed programmer that periodically reloads the rocket control system as it exhausts its commands.

Thermal control will be passive through use of blankets of multi-layer metallized mylar and nylon mesh. A heat rejection port will be provided in the prime instrument aperture to dump heat built up by equipment operation. In EOP missions to observe the Sun, the rejection port will be on the opposite side. Battery power will be used to maintain temperature in a 0-50°C range.

Electricity will be provided either by a Yardney LR130 (two packs) weighting 82-kg and providing 8-kWh of power, or a Yardney LR350 weighing 113-kg and providing 14-kWh. Each is a sealed silver-zinc battery in an electrically isolated, pressurized case.

In a typical mission, the EOP will receive about 12 minutes of crew check-out, essentially turning it on and letting EOP verify its own health. Another 30 minutes will be required to grapple the EOP with the Orbiter's remote manipulator system, position, then release. This positioning sequence will substitute for alignment of STRAP when a rocket is placed in the launch tower. The orbiter then separates to a distance of 1.5-3.0 km and carries out other functions while the EOP operates under its own command. After about 24 hours, the Orbiter closes on the EOP operates under its own command. After about 24 hours, the Orbiter closes on the EOP using rendezvous radar to seek out corner reflectors on the EOP. Slightly more than an hour is needed to close, grapple, and stow. The EOP sits in the payload bay until landing when it is returned to Goddard and the data tapes are distributed to the investigators. Data retrieval on film will be possible, too, depending on the science package.

A second EOP design being considered by Busse's office would be compatible with the Aries sounding rocket. Most sounding rockets are on the order of 0.5-m wide; Aries is 1.1-m wide (see *Spaceflight:*) and offers investigators a launcher for larger payloads. It also offers the possibility of flying two, possibly three, 0.42-m payloads from smaller rockets plus an additional canister with support systems (for a total of three or four canisters inside the Aries canister). Such an EOP could support Aries-class experiments or a cluster of smaller experiments plugged in without modifications to the box-like EOP.

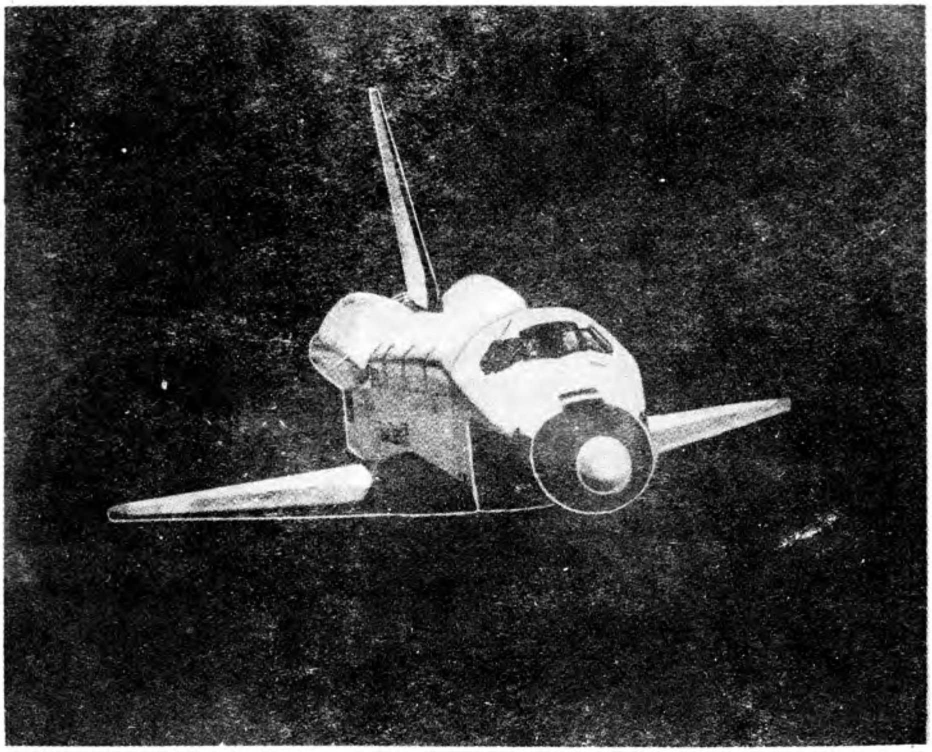
Materials Processing

Another possibility being considered for an early EOP mission is in materials processing in space. Marshall Space Flight Center took the lead in adapting sounding rocket hardware to Shuttle by using gear and lessons from the Space Processing Applications Rocket (SPAR) programme to develop the Materials Processing Assembly (MEA-1). This will be a cluster of four SPAR-type experiments in a box with batteries, thermal control, and data processing and operational control. At present, MEA-1 is a box 1.69 x 1.1 x 1.1-m weighing 1134-kg. Like EOP payloads, it is completely self-contained, requiring only that the Shuttle not manoeuvre during processing. EOP may free Shuttle and MEA-1 of each other (9).

Busse said that a quick look at the two systems shows that EOP can provide MEA-1 with the stability it requires. Because the two are self-contained, little interfacing would be required. The principal issue is whether activities aboard MEA-1 would prove to be more than EOP can handle. A tennis match aboard an ocean liner would hardly be noticed, but would obviously rock a rowboat. Processes planned for MEA-1 are being examined to make sure they would not overwhelm EOP's control capabilities. West Germany's MAUS, similar to MEA-1 in using TEXUS gear, conceivably might also fly with EOP.

In (2), the authors estimate that it will cost \$1.06 million to develop EOP for its first flight and \$562,000 to refurbish for each subsequent flight. This includes data reduction and travel. These figures are in 1977 dollars and do not include the Shuttle

Returning to Earth. Orbiting for periods of 7 to 30 days, the Shuttle Orbiter uses its manoeuvre engines to adjust its path, for rendezvous operations, and at the end of its mission, for braking manoeuvres taking it out of orbit. It re-enters the Earth's atmosphere with the nose pitched up at 30°, endures a period of frictional heating and glides back to base. *NASA*



flight costs. Based on the fiscal 1980 rates, the cost to ride the Shuttle would be $470,000, based on weight. Thus, the first flight cost would be about $1.53 million, and each reflight about $1.03 million, versus $300,000 for each Aerobee flight. The pay-off comes in the data collected. On an Aerobee flight, data is acquired at the rate of 500,000 bits per second for 300 seconds (typical), for a total of 150 million bits. On EOP, a maximum of 1 million million bits can be collected (the limit of the tape recorder in its planned 24-hour operation. Observing time thus costs $1,000 per second for Aerobee and $12-17.70 for EOP. A single bit of data will cost 0.2 cents U.S. on Aerobee, and a mere 0.010-0.015 cents U.S. on EOP.

But despite the obvious attractions of EOP, other users are not lining up.

"People are sceptical about lead time and flexibility," said T. Bland Norris, director of astrophysics for NASA [9]. "A lot of work with sounding rockets is done by graduate students. They need something that can be done in the gestation period of doctoral research," usually a year or two.

First experiments to fly aboard the Shuttle will do so more than four years after they were selected, five in the case of Spacelab 1. NASA wants to reduce that cyle for all concerned.

"We're hoping that for this class of mission, the Shuttle will be just as responsive as sounding rockets," Norris said.

Ultimately, though he expects that virtually all of the astronomy and solar physics sounding-rocket flights may be captured by Shuttle, about half as EOPs and the rest as Spacelab payloads. Ionospheric experiments may remain rocket-based partly because of the demands of latitude and unpredictability of phenomena.

To make the EOP attractive, NASA will probably have to reserve space for it so quick-reaction payloads could be flown at the last moment, but that consideration has yet to take form.

"For right now it seems to me that the important thing is to give the users confidence," Norris said.

Another driver towards EOPs will be the increasing demand of payloads and the fixed capability of sounding rockets. "In effect we will be putting a cap on sounding rocket payload capability. Unless there's some clear indication that there's something better to do, no one is going to put up any money to enhance sounding rocket capability."

And Cruddace in [2] wrote:

"No matter how great the changes wrought by the big instruments..... there will always be the need to fly a variety of smaller instruments. Sounding rockets are rapidly becoming unproductive due to their small observing time, and the conventional method of launching satellites costs too much and requires lengthy preparation.

"The Space Shuttle has arrived just in time (but is) a new technique and its cost is very uncertain. We feel it equally important to explore another technique, based on sounding rocket experience and promising to be relatively inexpensive, for flying small payloads as ejectable, self-contained, preprogrammed units that rely on the Shuttle primarily as a replacement for the sound rocket propulsion."

Here is a survey of other work in this field.

Military payloads

The U.S. Army Ballistic Missile Defence programme office (descendant of the short-lived Safeguard anti-missile system) has studied a Shuttle-born target measurements plan. This would place advanced sensors, now launched by Castor 4 rocket, aboard the Shuttle for similar tests in orbit. The sensor is the Designating Optical Tracker, or DOT, which uses super-cooled optics to track incoming re-entry vehicles, launched by Minuteman 2 or 3 ICBMs, against the deep-cold background of space. Although the Army has declined to identify exactly what it observes, it is generally conceded that they are models of Soviet and Chinese re-entry vehicles, decoys, booster fragments, and possibly U.S. vehicles to determine how they may appear to enemy defenses.

DOT is launched from the Kwajelein Atoll Missle Range in the South Pacific; two flights have been made by early 1980. Afterwards, the package is retrieved from the ocean. The Army has said little about its Shuttle targets measurement plan, but it probably would carry two packages, one with DOT and the other with targets. The DOT package probably would be the manoeuvrable one to view the targets in various aspects of the sky. The Army has taken great care to point out that such a Shuttle cargo would carry no weapons, only sensors,

although these support development of an advanced ICBM interceptor. Parallel feasibility studies were conducted by Rockwell International and TRW, but no results have been announced.

Detached Experiment Carrier

In contrast to the simplicity of the EOP, there is the elegant DEC proposed [4] by the same Johnson Space Center crew that is developing the Manned Manoeuvring Unit for Space Shuttle astronauts (see *Spaceflight*, Vol 21, p.252). Indeed, DEC would be a remotely-controlled MMU carrying small payloads or a television camera.

"The carrier is a compact vehicle that is radio-controlled by the Shuttle crew," Ritz and Whitsett write. "It uses control television, command, and cold gas propulsion systems to deploy experiments from and later rendezvous with the Orbiter.

DEC would be a box, like EOP, 9.9 x 1.1 x 1.1m and weighting 286-kg, including payload. It would operate up to 2.8-km from the Orbiter. Principal systems would be drawn from the MMU design, with the TV systems coming from the manoeuvrable television system project conducted, briefly, at Johnson. A command station in the orbiter aft flight deck would allow an astronaut to operate DEC through the same hand controllers that will be used on the MMU.

Possible missions for DEC include carrying EOP-type payloads, testing experimental systems at a safe distance, carrying contamination instruments around the Orbiter, remote-control "parts jockey," photograph payloads inside the Orbiter, and growth into a teleoperator system. One mission once given equal billing with others but assuming greater importance is inspection of the Orbiter's fragile heatshield. Cameras mounted on the end of the remote mainipulator system will be hampered by the limited reach of that mechanical arm. DEC would provide astronauts with a close-up view of any part of the orbiter and could be the vehicle for minor repairs.

European Sub-satellites

Since 1972 the European Space Agency (then ESRO) has examined the possibility of sub-satellites based on sounding rockets and launched by the Shuttle [6]. The concept is limited compared to EOP and DEC. According to R.A. Buckland of ESA, the sub-satellites were conceived to support Spacelab missions in the discipline of Atmosphere, Magnetosphere, and Plasama in Space (AMPS). Initially there was little enthusiasm, but a new working group in 1977 brought forth the claims that "Simple sub-satellites could be built..... At the same time it became apparent in ESA that the adaptation of sounding rocket technology to sub-satellites could be very cost-effective." Two design contracts were issued, one to British Aerospace, the other to Kayser Threde GmbH of Germany.

Guidelines for the studies were that the unit cost should be 200,000 accounting units (1977 prices) for a production run of 10 units in five years; maximum use would be made of sounding rocket hardware and "do-it-yourself" philosophy would be examined. Minimum size would be 15-kg of payload, 10-W power to the payload, 24 hours of operating time, and a data rate of 20 kilobitts/second at 64-km range. Interest of the science community is being assessed.

"In this context, Spacelab sub-satellites have been included as a multi-user facility in the recently issued Preliminary Call for Experiment Proposals for the early phase of Spacelab utilization in Europe," Buckland wrote.

The British Aerospace design, produced by its Bristol Division, is based on its Skylark rocket [7] (see *Spaceflight*, May 1980). The baseline sub-satellite would be a magnesium cylinder 0.44-m wide by 0.31-m high. Up to 0.025 of the 0.045-m³ volume would be available for experiments, and 24 of the 60-kg mass. Nickel-cadmium batteries will provide power. and a spin-stablization system will provide attitude control. Thermal control is passive. Data is transmitted on S-band to the Orbiter.

Options are available for upgrading the design, including an additional canister on top of the basemodule, or an enlarged sub-satellite 0.66-m wide by 0.40-m tall offering three times as much volume and mass to experiments.

The Kayser Threde design is somewhat larger than the BAe design: 0.60-m wide by 0.45-m tall weighing 85-kg. The experiments would have a volume full width and 0.25-m deep and could weigh up to 15-25-kg. The sub-satellite would be spin-stabilized. Because the RMS would not be carried on every Shuttle flight, the Kayser LThrede craft could redock itself with the Shuttle Orbiter. Data would also be transmitted to the Orbiter at 64 kilobits/second at ranges out to 200-km.

Multiprobes

Among the experiments selected by NASA for Spacelab in August 1979 are the magnetospheric multiprobes, with Dr. J.L. Burch of Southwest Research Institute as the principal investigator [10]. A cluster of six would be deployed by the Orbiter to fly in an array that would gradually reach into the upper reaches of the atmosphere, permitting simultaneous measurements of electric and magnetic fields and electron densities and temperatures. Each probe will be a spin-stablized sub-satellite 0.6-m wide, 0.38-m tall, and weighing 50-kg. They would not be retrieved.

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THE COSMONAUTS - Part 19

by Gordon R. Hooper

Continued from November-December 1980 issue

Above: The crew of Soyuz 36, Valery Kubasov and Hungarian Bertalan Farkas, resting after routine training.
Novosti Press Agency

Bela Magyari, back--up cosmonaut for the Soyuz 36 mission.
Theo Pirard

Lt. Colonel Bertalan Farkas

Bertalan Farkas was born on 2 August 1949 in the village of Gyulahaza in North-East Hungary, the son of a shoe-maker. His father worked in a shoe-maker's co-operative workshop in Kisvarda, where Farkas attended the Gyorgy Bessenye secondary school. He was interested in aeronautics from a very early age, and while a youth, joined the club of the Hungarian National Defense Association at Nyiregyhaza, and began making glider flights. After graduating from secondary school in 1967, he enrolled in the Gyorgy Kilian Aeronautical Engineering College in Szolnok. Upon graduation in 1969, he went to the Soviet Union to continue his training.

Farkas was commissioned as a 2nd Lt. in the Hungarian People's Army in 1972, and joined the Air Force. He joined the Hungarian Socialist Workers' Party in 1976, and in 1977 he qualified as a fighter-pilot 1st class. In 1978, he was promoted to Captain (Squadron-leader), having been especially successful in complicated manoeuvres at high altitude, and in manoeuvring during combat training. He was decorated 5 times and repeatedly praised for the performance of his duties.

Following the Intercosmos agreement under which the Soviet Union offered to fly non-Soviet cosmonauts onboard Soviet spacecraft, Hungary began a cosmonaut selection programme. Farkas was one of the two finalists, and he arrived for duty at Star Town on 20 March 1978. After nine months of basic training, he was teamed with Valery Kubasov in December 1978. The two men were launched into space aboard Soyuz 36 on 26 May 1980, and docked with the orbiting space-station Salyut 6. They joined the station's crew of Popov and Ryumin and carried out a series of joint Soviet-Hungarian experiments before returning to Earth after a flight lasting 7 days 20 hours and 46 minutes.

Upon his return, Farkas was promoted from Captain to Lt. Colonel and received many honours and awards, including:- the titles of Hero of the Soviet Union, Hero of the Hungarian People's Republic, and Cosmonaut of the Hungarian People's Republic; the Golden Wreath Badge of the Hungarian-Soviet Friendship Society and the Order of Lenin and Gold Star Medal.

Farkas is married, and his wife Anniko is a photographer. They have a 9 year old son Gabor, and a 3 year old daughter, Aida. Farkas has been described as "a highly disciplined and politically thoroughly trained officer, with a high degree of self-control." Kubasov has said of him: "Very serious, a good specialist, very quick reactions, grasps everything at once, a charming person and sociable; I value his sincerity and sense of responsibility. You can always rely on him."

Farkas is known as Bertsi to his friends (an abbreviation of Bertalan). When asked what his hobbies were, he replied that he was very keen on football - so much so that he was at a loss to know which career to choose - football or flying.

Bertalan Farkas was the 5th Intercosmos cosmonaut.

Major Bela Magyari

Bela Magyari was born in August 1949, in Kisfunfelegyhaza in Southern Hungary. After completing his secondary studies, he became a student at the Gyorgy Kilian Aeronautical Engineering College in Szolnok in 1967. Upon graduation in 1969, he went to the Soviet Union to continue his studies.

He was made a Flight-Lt. in 1972, and was assigned to the Hungarian Air Force. He was promoted to Captain (Squadron-leader) in 1978. Magyari was awarded the title of Fighter-pilot 3rd class in 1973, and promoted to first class in 1977. He joined the Hungarian Socialist Workers Party in 1974. He has been decorated 4 times.

Following the Intercosmos agreement under which the Soviet Union offered to fly non-Soviet cosmonauts onboard Soyuz and Salyut spacecraft, Hungary began looking for prospective candidates. Magyari was eventually selected as one of two finalists to be sent for training in the Soviet Union. He arrived in Star Town on 20 March 1978, and following nine months of general training, he was teamed up with Vladimir Dzhanibekov in December 1978. Magyari served as back-up to Bertalan Farkas, and acted as CapCom during the Soyuz 36 flight, launched on 26 May 1980.

Following the successful completion of the mission, Magyari was promoted from Captain to Major "in recognition of outstanding preparations for the joint Soviet-Hungarian spaceflight." He received many awards and honours, including:- the Order of the Banner of the Hungarian People's Republic, adorned with laurel wreath; the Golden Wreath badge of the Hungarian-Soviet Friendship Society; and the title of Cosmonaut of the Hungarian People's Republic.

Bela Magyari is married, and his wife is an administrator. They have a 4 year old daughter named Greta. Magyari's father is a school caretaker, and his mother an administrator.

French Trainee Cosmonauts

Under the terms of the Intercosmos agreement signed on 14 September 1976, the Soviet Union offered to fly cosmonauts from Bulgaria, Cuba, Czechoslovakia, the GDR, Hungary, Mongolia, Poland, and Romania onboard Soviet spacecraft in the period 1978-83. The first such flight began on 2 March 1978 with the launch of Vladimir Remek from Czechoslovakia. In the period April - June 1979, three more countries were invited to take part in joint spaceflights.

In May 1979, it was reported that Vietnam had joined the Intercosmos programme, and Vietnamese cosmonauts were already in training at Star Town. And in June 1979, it was announced that as an extension of its space co-operation programme with India, the Soviet Union had offered India a joint spaceflight.

In the course of President Giscard d'Estaing's visit to the Soviet Union in April 1979, Leonid Brezhnev proposed that a French cosmonaut take part in a Soviet spaceflight. This proposal was duly considered and accepted.

The French space agency CNES (Centres National d'etudes Spatiales) called for volunteer cosmonauts, and received in excess of 400 applications. From these, two finalists were eventually chosen on 12 June 1980, and were due to commence training at Star Town in September 1980. One will fly as researcher onboard a Soyuz mission to Salyut 7 in the first quarter of 1982, whilst the other will serve as back-up and then CapCom at Soviet MCC.

The two French cosmonaut candidates are:-

Lt. Colonel Jean-Loup Chrétien

Jean-Loup Chrétien was born on 20 August 1938, in La Rochelle, France. In 1959 he entered the Air School, Salon de Provence, and graduated as a pilot-engineer in 1961. He was promoted to Lieutenant in 1962, and from 1962-69 served as a fighter-pilot in a Mirage Combat Squadron. In 1970 he was assigned to the Test Pilot School at Istres, and spent seven years there as a test-pilot, and was in charge of flight-testing for the Mirage F-1 fighter.

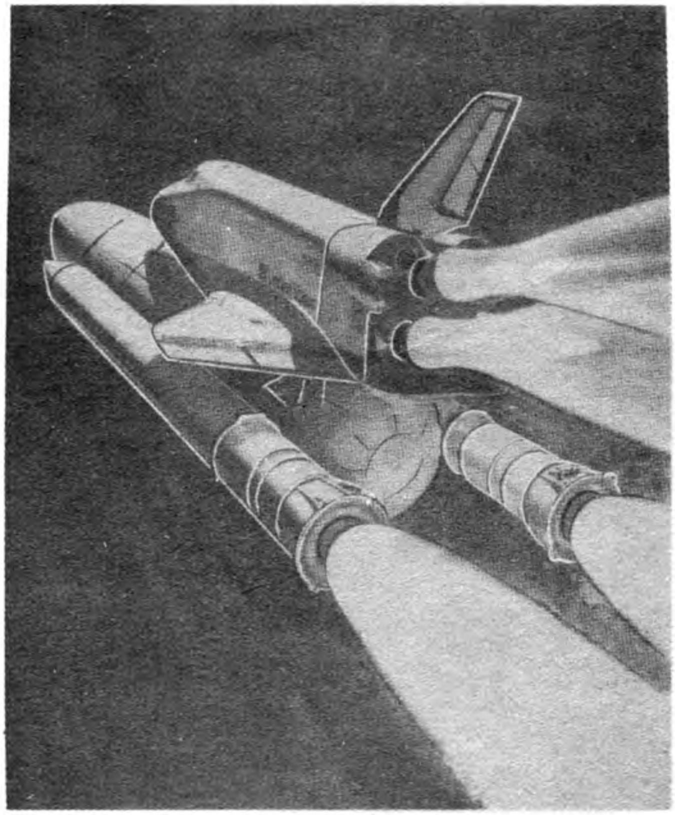
In 1978, he was attached to the Commander, Air Defence Zone South, and has accumulated over 5000 hours flying time.

Lt. Colonel Chrétien is married, and has four sons, aged 18, 15, 14 and 5. His hobbies include skiing and sailing.

Major Patrick Baudry

Patrick Baudry was born on 6 March 1946 in Cameroon, France In 1967, he entered Air School and graduated in 1969 as a pilot-engineer. From 1969-75 he served as a pilot in an operational Jaguar squadron, and from 1975-76 was assigned to the Empire Test Pilot School. He then served as a test-pilot at the Test Flight Centre at Bretigny-sur-Orge, and has accumulated over 3000 hours flying time.

Baudry is married, and has a 4 year old daughter. His hobbies include skiing, motorcycling and squash. He also has a collection of wines.



SATELLITE DIGEST — 143

A monthly listing of all known artificial satellites and spacecraft. A detailed explanation of the information presented can be found in the January, 1979 issue, p. 32.

Robert D Christy

Continued from January issue

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclination (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
GOES 4 1980-74A 11964	1980 Sep 9.935 indefinite	Cylinder 627 fuelled	2.3 long 1.9 dia	34257 35774	39965 35800	0.33 0.19	1504.18 1436.0	ETR Delta NOAA/NASA (1)
Soyuz 38 1980-75A 11977	1980 Sep 18.799 7.883 days (R) 1980 Sep 26.662	Sphere+cone- cylinder 6800?	7.5 long 2.2 dia	195 205 338	256 293 350	51.60 51.62 51.63	88.95 89.42 91.36	Tyuratam A-2 USSR/USSR (2)
Cosmos 1210 1980-76A 11980	1980 Sep 19.42 14 days (R) 1980 Oct 3	Cylinder+sphere +cylinder-cone? 6000?	6 long? 2.4 dia?	179 227 233	243 321 359	82.29 82.33 82.34	88.76 90.04 90.49	Plesetsk A-2 USSR/USSR (3)
Cosmos 1211 1980-77A 11982	1980 Sep 23.44 11 days (R) 1980 Oct 4	Sphere+cylinder- cone? 5500?	5.5 long? 2.4 dia?	215	240	82.35	89.09	Plesetsk A-2 USSR/USSR (4)
Cosmos 1212 1980-78A 11985	1980 Sep 26.42 13 days (R) 1980 Oct 9	Cylinder+sphere +cylinder-cone? 6000?	6 long? 2.4 dia?	208	247	82.34	89.11	Plesetsk A-2 USSR/USSR (5)
Progress 11 1980-79A 11993	1980 Sep 28.632	Sphere+cone- cylinder 7000?	8 long 2.2 dia	189 269 333	247 340 339	51.63 51.62 51.62	88.79 90.55 91.19	Tyuratam A-2 USSR/USSR (6)
Cosmos 1213 1980-80A 11997	1980 Oct 3.50	Cylinder+sphere +cone-cylinder? 6000?	6 long? 2.4 dia?	195 227 230	316 287 296	72.87 72.87 72.86	89.65 89.69 89.81	Plesetsk A-2 USSR/USSR (7)
Raduga 7 1980-81A	1980 Oct 5.71 indefinite	Cylinder+2 panels +antenna array 5000?	5 long? 2 dia?					Tyuratam D-1-E USSR/USSR (8)
Cosmos 1214 1980-82A 12008	1980 Oct 10.55	Cylinder+sphere +cylinder-cone?	6 long? 2.4 dia?	172	345	67.15	89.70	Plesetsk A-2 USSR/USSR (9)

Supplementary notes:

(1) Geostationary Orbiting Environmental Satellite returning meteorological data from orbit. Its location is above 90 degrees west longitude, and the satellite is operated by the US National Oceanographic and Atmospheric Administration. Orbital data are at 1980 Sep 14.2 and Oct 3.2.

(2) Manned ferry vehicle carrying international crew of Yuri Romanenko and Arnoldo Tamayo Mendez to Salyut 6. Soyuz 38 docked with Salyut 6 at 2049 UT on Sep 19 (Sep 19.867). Orbital data are at 1980 Sep 18.8, 18.9 and 20.0.

(3) Possibly an Earth resources satellite. Orbital data are at 1980 Sep 19.4, 20.7 and Oct 2.3.

(4) Possibly an Earth resources satellite.

(5) Possibly an Earth resources satellite. Cosmos 1212 carried out a number of very small manoeuvres during the course of its flight. Its orbit plane was very close to that of Cosmos 1211.

(6) Unmanned cargo ferry carrying supplies to Salyut 6, to enable extension of its orbital lifetime beyond the recovery of Soyuz 37 on Oct 11. Orbital data are at 1980 Sep 28.8, 30.2 and Oct 1.2.

(7) Orbital data are at 1980 Oct 3.6, 4.5 and 12.1.

(8) USSR communications satellite at the Statsionar 1 location (84 degrees east longitude), in geostationary orbit.

(9) Long life, manoeuvrable reconnaissance satellite.

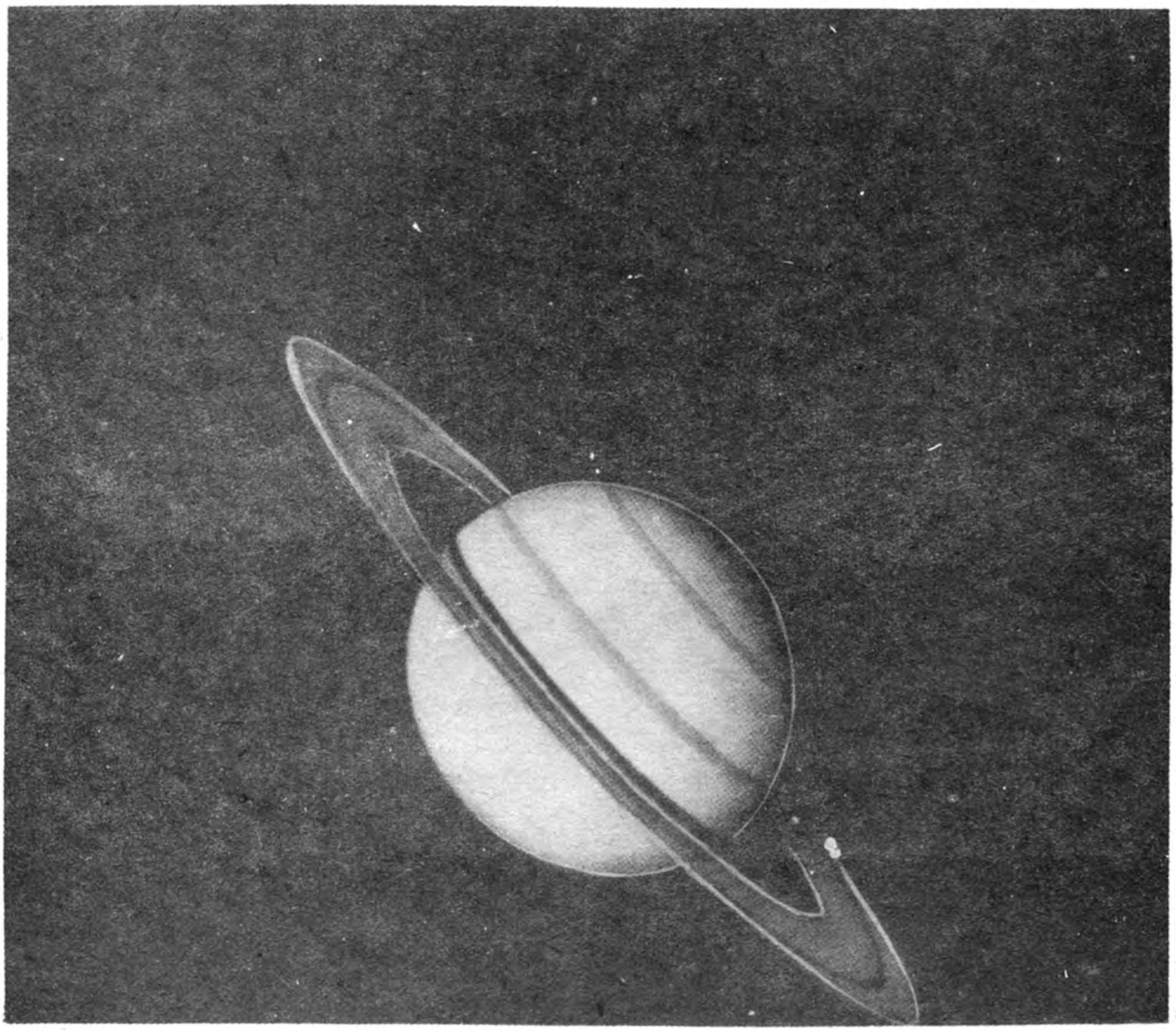
Amendments

1979-17A. Solwind launch vehicle is Atlas Burner 2.

1979-49A. Soyuz 34 orbit dates are 1979 Jun6.9, 7.4, 8.3 and 9.5 respectively.

Continued overleaf

FOCUS ON SATURN



Voyager 1 took this picture when the spacecraft was still 47 million miles (76 million km) and eight weeks away from its encounter with the giant ringed planet, capturing five of the planet's moons in the frame. Saturn's largest moon, Titan, is seen in the upper right corner. The smaller satellites, Dione and Tethys, are shown in the upper left corner (upper and lower respectively.) Two of the innermost satellites, Mimas and Enceladus, appear to the lower right of the planet, Mimas being the closer one to Saturn. The bright object to the left of the rings is not a moon but an artifact of processing. Voyager 1 flew past Saturn at a distance of 124,200 km (77,176 miles) on 12 November 1980. Scientists still examining the remarkable results of the mission now believe the theory that the rings were formed by moons disrupted by the gravitational field of Saturn is incorrect. The mechanism which gave Saturn its ring of ice "is the same process that formed the Solar System - a slow accretion of particles formed by a cooling gas cloud." More than 17,000 photos were taken of Saturn and its rings and satellites during the encounter. We shall be reporting on the results in future issues. In the meantime, on page 35, we began a review of the entire Voyager programme from its beginning in the early optimism for the Grand Tour. ***NASA/JPL***

Satellite Digest - 143/*contd.*

Amendments

1979-52A. Cosmos 1105 was an Earth resources satellite.

1979-63A. Cosmos 1112 decayed 1980 Jan 21, lifetime 199 days.

1979-80A. Cosmos 1127 was an Earth resources satellite.

1980-87A. Ekran 4 weight should read 5000 kg?

1979-102A. Cosmos 1147 was recovered 1979 Dec 26.3 after 14 days.

1980-64A. Soyuz 37 was recovered 1980 Oct 11.410 (0950 UT) after 79.637 days. It carried the long stay crew of Leonid Popov and Valery Ryumin back from Salyut 6 after a flight lasting 184 days 20 hours 12 minutes.

1980-71A. Cosmos 1208 was recovered 1980 Sep 24, lifetime 29 days.

1980-49A. Horizont 4 launch date should read 1980 Jun 14.03. Add a second orbit at 1980 Jun 27.3 of 35744 × 35827 km, 0.81 deg, 1435.95 min.

THE BRITISH INTERPLANETARY SOCIETY
LIMITED *(by guarantee)*

27/29 South Lambeth Road, London SW8 1SZ

NOTICES OF MEETINGS

Technical Forum
Topic: **MILITARY SATELLITE PROGRAMMES**
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on Friday, **23 January 1981**, 6.30–9 p.m.
Offers of Papers are invited. Further information may be obtained from the Executive Secretary of the Society.
Members with a special interest in Military Satellite Programmes are invited to attend. No fee is payable, but registration *is* necessary. Forms are available from the Executive Secretary on request, enclosing a reply-paid envelope.

Lecture
Title: **DEVELOPMENTS IN CIVIL SATELLITE COMMUNICATION**
by J. Adams and P. Moss
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on Wednesday, **4 February 1981**, 7–9 p.m.

Admission is by ticket only. Members wishing to attend should apply in good time, enclosing a reply-paid envelope.

Study Course
Title: **ROCKET TECHNOLOGY**
Seventh lecture: **Advanced Propulsion – What Future for the Rocket?** by Dr. R. C. Parkinson.
Venue in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **11 February 1981**, 7 p.m. Course fee is £5.00.

Application forms available from the Executive Secretary, enclosing reply-paid envelope.

Lecture
Title: **ROLE OF A PRINCIPAL SCIENTIFIC INVESTIGATOR IN SPACE PROJECTS**
by Dr. G. E. Hunt
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on Wednesday, **25 February 1981**, 7–9 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course
Title: **ROCKET TECHNOLOGY**
Eighth lecture: **Sizing of Multi-Stage Rockets** by Prof. I. E. Smith.
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **4 March 1981**, 7 p.m. Course fee is £5.00. Application forms available from the Executive Secretary, enclosing reply-paid envelope.

Film Show
Theme: **EUROPE IN SPACE**
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **11 March 1981.**

Admission by ticket only, available from the Executive Secretary, enclosing a reply-paid envelope.

All-Day Visit
Visit to the **Royal Aircraft Establishment**, on **18 March 1981.**

Registration is necessary. Interested members should contact the Executive Secretary, enclosing a reply-paid envelope.

Lecture
Title: **ASPECTS OF ROCKET PROPULSION**
by M. R. Fry
Venue is the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **26 March 1981**, 7–9 p.m.

Admission by ticket, available from the Executive Secretary, enclosing a reply-paid envelope.

Lecture
Title: **THE INFRARED ASTRONOMICAL SATELLITE (IRAS)**
by Dr. R. Holdaway
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **8 April 1981**, 7–9 p.m.

Admission by ticket, available from the Executive Secretary enclosing a reply-paid envelope.

Symposium
Theme: **SPACE TRANSPORTATION SYSTEMS FOR THE 1990's — Requirements and Solutions**
Offers of Papers are invited for presentation at a one-day meeting to be held in the Golovine Conference Room, Society HQ, 27/29 South Lambeth Road, London, SW8 1SZ on **15 April 1981**, 9.30 a.m. to 4.30 p.m.

Registration forms and copies of the Final Programme will be available from the Executive Secretary in due course. Please enclose a reply-paid envelope with request.

Lecture
Title: **THE PHILATELY OF THE SOVIET SPACE PROGRAMME**
by Rex D. Hall
Venue is the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **29 April 1981**, 7–9 p.m.

Admission by ticket only. Apply to the Executive Secretary, enclosing a reply-paid envelope.

One-Day Discussion Meeting
DAEDALUS IN RETROSPECT
A one-day discussion meeting on Project Daedalus, three years after completion of the study, to be held in the Golovine Conference Room, at the Society's HQ Building, 27/29 South Lambeth Road, London SW8 1SZ on **6 May 1981**, 9.30 a.m.–4.30 p.m.
The Daedalus concept will be reviewed in the light of work appearing since the study, and various areas of investigation stimulated by the Project will be discussed. Offers of short contributions to the discussion should be made to Dr. A. R. Martin, c/o British Interplanetary Society, at the above address.
Members wishing to attend should apply in good time to the Executive Secretary, enclosing a reply-paid envelope.

Film Show
Theme: **THE MAKING OF AN ASTRONAUT**
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **20 May 1981**, 7–9 p.m.

Admission by ticket only, available from the Executive Secretary, enclosing a reply-paid envelope.

Continued overleaf

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Technical Forum
Theme: **THE SOVIET SPACE PROGRAMME**
with contributions by several speakers
Offers of papers are invited. Venue is the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **29 May 1981**, 6.30-9 p.m. No fee is payable but registration is necessary.

Application forms available from the Executive Secretary, enclosing a reply-paid envelope.

Lecture
Title: **SPACELAB**
by Dr. M. J. Rycroft
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **3 June 1981**, 7-9 p.m.

Admission is by ticket only, available from the Executive Secretary, enclosing a reply-paid envelope.

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

BIS DEVELOPMENT FUND APPEAL

£75,000 STAGE-2 APPEAL

As Members now know the BIS Development Programme successfully achieved its first objective last year with the move of the Society's offices to our new Headquarters Building.

Needless to say we want to see the Development Programme go ahead without delay, and to this end the Council decided in May to open an Appeal Fund with a target of £75,000 to follow on our successful first Appeal which ran for five years and closed in excess of its target at over £30,000.

Within the framework of its Development Programme the Society intends to play an increasingly active role in the world-wide growth of Astronautics, in promoting Space Exploration for the benefit of mankind and in serving the interests of its members in these fields.

In these times of high inflation Members' annual dues are largely taken up by the day-to-day running costs of the Society and extra financial support is needed to run a progressive programme of development and expansion. Being an independent body unsupported by Government funds the Society, in contrast with many other bodies, has always had to rely on the generosity of its Members to contribute over and above the normal subscription rate.

The first objective of the Appeal is to repay the £30,000 Bank Loan which covered the construction costs of the final stage of the new building. With the very high interest charges that are currently being incurred by the Society the urgency of the Appeal can hardly be over stressed.

Please take this opportunity to recognise the work and needs of the BIS by sending a donation to the Stage-2 Appeal. I can most confidently assure you that your donation will really count whatever the amount. Please give generously.

G.V.E. Thompson

President.

Please send your donation to the Executive Secretary at the above address.

Call for Papers

32nd INTERNATIONAL ASTRONAUTICAL FEDERATION

The 32nd Congress of the International Astronautical Federation will be held in Rome, Italy, from 6-12 September 1981. The theme will be SPACE: MANKIND'S FOURTH ENVIRONMENT devoted to "promoting awareness about the challenges and debating the problems posed by the use, further exploration and management of this fourth environment." The theme will then be developed through a series of symposia and technical sessions organised by the IAF and by the International Academy of Astronautics (IAA), dealing with:
1. Fourth environment; 2. Its exploitation and further exploration; 3. Its management and 4. The development of the needed 'soft' and 'hard' technologies.

Members of the Society wishing to present papers are asked to notify Dr. L.R. Shepherd, Chairman of the BIS International Liaison Committee at Society H.Q. as soon as possible.

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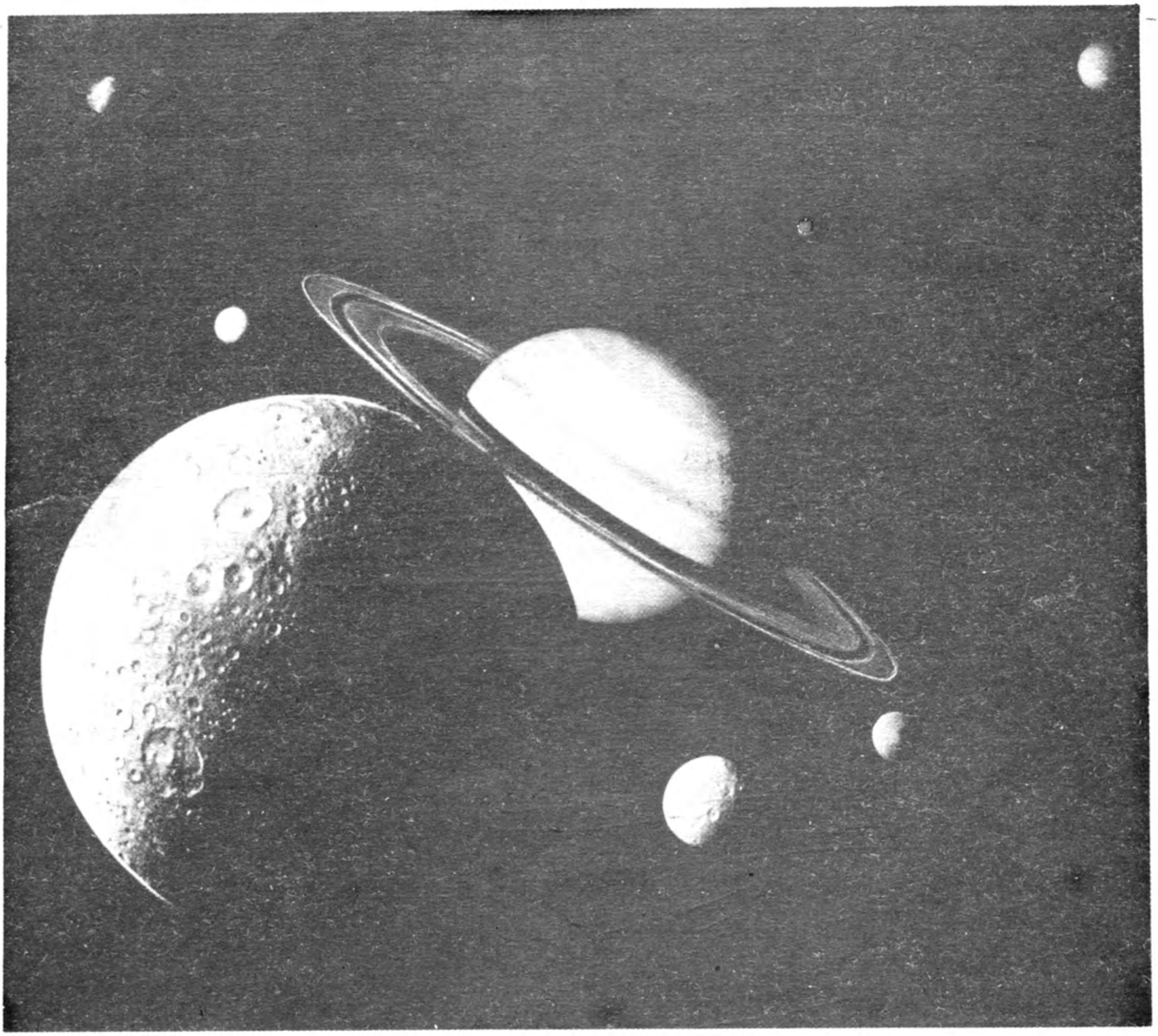
SPACEFLIGHT



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VOLUME 23 No 3
MARCH 1981

THE BRITISH INTERPLANETARY SOCIETY
LIMITED *(by guarantee)*

27/29 South Lambeth Road, London SW8 1SZ

1981 SUBSCRIPTION FEES

The rates payable for the various grades of Membership for the calendar year January-December 1981 are as follows:-

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£14.00	$35.00
Between 18 and 20	£16.00	$40.00
21 years of age and over	£18.00	$45.00
Associate Fellows	£20.00	$50.00
Fellows	£20.00	$50.00

Age Allowance

A deduction of £2.00 ($5.00) is allowed to members of every grade who are over the age of 65 years on 1 January 1981.

JBIS Subscription Rate

The additional subscription payable for *JBIS*, where required in addition to *Spaceflight*, is £16.00 ($40.00).

Methods of Payment

Payment should normally be made in sterling with a cheque which shows a UK address, either of the paying Bank or its Agent, where it can be presented for payment.

(b) Payments by US dollar cheques will be accepted if drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $10.00 to cover bank and collection charges.

(c) US dollar notes are accepted. Other currencies may also be accepted with prior agreement by the Society. Their value must be sufficient to include conversion costs into sterling.

(d). US or Canadian moner orders can only be accepted *if expressed in Sterling. Internal* money orders from these countries i.e. those expressed payable in dollars will be returned as they are not cashable in the UK.

(e) Most Canadian banks have UK branches or agents: remittances may easily be made in sterling drawn on those agents. If payment is made in Canadian dollars the current exchange rate must be used, plus the addition of 12 Canadian dollars to cover exchange and collection charges.

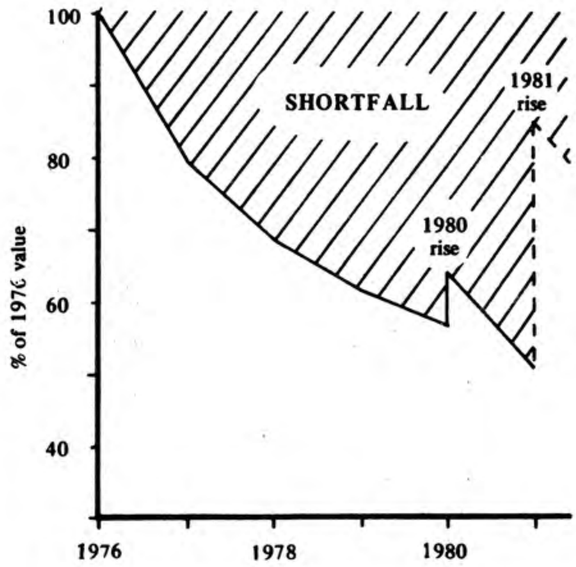
(f) Cheques drawn in sterling on banks in Europe (including Euro-cheques) must include £4.00 to defray bank charges and collection costs.

(g) Banks which remit directly to the Society must be instructed by members to see that the sum transmitted is *free of deductions.* (Banks frequently impose charges "in transit," so the amount actually received by the Society is insufficient to pay for the subscription thus causing much additional correspondence and trouble both to the members concerned and to the Society).

(h) Remittances from Europe can be made by GIRO: this is the easiest and cheapest method of transferring funds. Our GIRO account number is 53 330 4008.

Space Transportation Working Group Members having technical expertise in space transportation systems and who are prepared to participate in a Discussion Group should contact the Executive Secretary for further details.

BIS subscription rates for 1976-81



BIS subscription rates for 1981 are less *than those of 1976 in real terms.*

The graph shows how inflation over the last five years has reduced the purchasing power of membership income to 50% of that in 1976. The shaded area represents the accumulative shortfall in Society income over this period. It is seen that the 1981 rise in subscription rates only partly compensates for the effects of inflation. **This increase has become necessary in order to maintain services and publications to members. Please give the Society your support by returning the Membership Renewal Form as soon as possible.**

THE SOCIETY'S LIBRARY: OUR NEED FOR BOOKS

Dear Member,

We are undertaking a substantial effort in endeavouring to build up a Specialised Space Library for the Society, though our efforts are greatly hampered by the fact that, in a period of rapidly-increasing inflation, the Society has no funds available for the purchase of books. This is why we need to rely solely on the goodwill of our members to help us acquire suitable material.

To support this Appeal, the Library Committee has asked me to write to each member of the Society who is known (or suspected) to be an Author of books of the right calibre on astronomy and space, to place our Appeal before them and seek their help, especially because the Committee particularly wishes to see that all relevant books published by members of the Society, even if they first appeared some years ago, appear on our shelves.

The Committee seek your support and hope that you will be willing and able to donate one or more copies of your works. Needless to say, if you have duplicates of any other material which you could consider parting with and donating to the Society, they would be extremely grateful for this too.

I hope you will be able to respond favourably.

L.J. CARTER
Executive Secretary

SPACEFLIGHT

A Publication of The British Interplanetary Society

Editor:
Kenneth W. Gatland, FRAS, FBIS

VOLUME 23 No. 3 MARCH 1981 *Published 15 February 1981*

CONTENTS

COVER

RICH HARVEST. This montage of images obtained by the Voyager 1 spacecraft during its close encounter with Saturn last November has been put together by JPL scientists. The picture shows Dione in the forefront, Saturn rising behind, Tethys and Mimas fading in the distance to the right, Enceladus and Rhea off Saturn's rings to the left, and Titan is in its distant orbit at the top.

National Aeronautics and Space Administration

MILESTONES

November 1980

21-23 Radio transmissions from Salyut 6 received by Western tracking stations indicate that Salyut 6 is being prepared for a new manned occupation. Salyut's orbit is 293 x 308 km, 90.46 minutes, 51.62 degrees inclination.

24 NASA moves Space Shuttle "Columbia" from Orbiter Processing Facility to Vehicle Assembly Building at KSC for mating with External Tank and Solid Rocket Boosters.

25 NASA offers Ball Aerospace Systems $21 million cost-plus award fee contract to integrate, test and deliver Earth Budget Radiation Satellite for launch by Space Shuttle by April 1984.

27 Soviets launch Soyuz T-3 spacecraft with cosmonauts Lt-Col. Leonid Kizim, Oleg Makarov and Gennady Strekalov at 1718 MT. Ships of this class use "an original on-board computing complex which frees the cosmonauts from many routine operations. Depending on the situation, this complex will itself select the best system of orientation, or approach with another spacecraft, and the plan of descent." T-series ships are about the same size and weight of earlier Soyuz ferries but many of the on-board systems are smaller and lighter.

28 Soyuz T-3 docks with Salyut 6 Progress 11 complex at 1854 MT. Object of mission is described as bringing Salyut 6's systems back into full manned operation and giving the station a thorough overhaul. Research tasks included the growth of higher plants, the manufacture of semi-conductor materials and use of a portable helium-neon laser to obtain a hologram of a crystal being dissolved.

28 Spacelab engineering model is accepted by NASA in roll-out ceremony in Bremen, West Germany. Engineering model - a non-flying prototype - will be used to verify interface of the Spacelab with ground equipment at KSC.

December 1980

1 India announces agreement with NASA to launch two Indian communications/meteorological satellites. The satellites, to be built by Ford Aerospace, will provide point-to-point voice links, direct-broadcast TV and weather information from geostationary orbit. To be known as Indian National Satellite (Insat) 1A and 1B, they will be launched by the Space Shuttle in 1983.

4 Space Shuttle main propulsion system is successfully static fired for 591 seconds at National Space Technology Laboratories, Bay St. Louis, Mississippi, exceeding the time required to place the Shuttle into Earth orbit. Firing was the 11th test of three-engine cluster and brought the total test time on the main propulsion system to nearly 3,200 seconds. This was in addition to more than 86,400 seconds of single engine tests that have been conducted in separate firings.

6 Intelsat 5 is launched by Atlas Centaur from Kennedy Space Centre, Florida, for stationing in geostationary orbit. The biggest communications satellite yet, it will relay 12,000 telephone calls and two colour television programmes between 105 member countries of the Intelsat consortium. Intelsat 5 was developed and constructed by an international industry team led by Ford Aerospace & Communications Corporation of the United States. The team also includes five European sub-contractors - Aérospatiale (France); GEC-Marconi (UK); Messerschmitt-Bölkow-Blohm (West Germany); Selenia (Italy) and Thomson-CSF (France) - as well as Japan's Mitsubishi Electric Corporation. There are 12 Intelsat V flight vehicles on order at present.

Continued on page 86

"COLUMBIA" ON THE PAD

After long delays, suddenly the Space Shuttle "Columbia" has reached the launch pad at the Kennedy Space Center and is being checked out ready for its maiden flight. Huge crowds are expected to gather to witness the launch as millions of people around the world watch events live by television.

It was on 24 November 1980 that the stubby winged craft was transferred from the Orbiter Processing Facility to the Vehicle Assembly Building where, two days later, it was mated with the External Tank and Solid Rocket Boosters on the Mobile Launch Platform.

A series of checks began with the Mobile Platform lift-off umbilicals and the External Tank tumble system; and the Orbiter's inertial measuring unit was calibrated. The Orbiter's main engine nozzles were gimballed and aerodynamic control surfaces - elevons, rudder/speed brake and body flap - were moved to check clearances. Tests were also made of the ability of the Orbiter's on-board computers to steer the Solid Rocket Boosters during the ascent into orbit. The boosters are steered by hydraulically moving the nozzles.

Then the spacecraft was powered up and its complex systems put through the most rigorous testing with the flight crew and mission control personnel taking part. Prime crew astronauts John Young and Robert Crippen, and backup crewmen Joe Engle and Richard Truly, participated in flight simulations which included ascents to orbit, return to launch site and single orbit aborts, and descents from orbit to landing.

There was also work on the Orbiter's thermal protection system to be completed, namely the closing of some 2,900 gaps between the thermal tiles. The gap filler closure rate averaged 275 per day.

It says a great deal for the efficiency of the hard-worked space teams that the bulk of this work was completed ready for the whole stack to be moved by the giant crawler to Launch Complex 39A so soon after Christmas. Then began 10 weeks of further tests including preparation for a critical 20 second firing of the Orbiter's three main engines on the pad.

The Space Shuttle Main Engine (SSME) is the most advanced liquid propellant engine ever built. It features high performance, variable thrust, long life (up to 55 flights before overhaul) and a total of 7.5 hours of operation. The SSME's are controlled by a built-in computer which performs ground checkout, in-flight diagnoses, and controls engine operation from start up, through various thrust levels and shutdown.

Mission and launch verification tests on the pad were being followed by countdown demonstration tests and, if all is well, pre-launch checkout begins at T-minus 120 hours.

In view of the advanced nature of the project, it would be surprising if there were no hidden snags in this procedure. It was already clear that the earliest launch date of 14 March would be exceeded but, all the same, solid progress had been made.

The actual lift-off - when it comes - will proceed as follows:

Min/Sec	
-00.07	Space Shuttle Main Engines start.
00.00	Solid Rocket Boosters ignite. Lift-off.
00.07	Vehicle clears tower.
00.52	Maximum dynamic pressure.
02.05	SRB's separate.
08.42	SSME's shut down
08.59	External Tank separates
10.43	Manoeuvre engines ignite to put spacecraft into orbit.

Much attention has been paid to emergency drills in case of engine problems after lift-off. Depending on the circumstances, the spaceplane would burn two of the three main engines for a longer period if one failed, or a decision could be made to return to the Cape. In the latter case, the vehicle must make a 180° turn and ditch its tank. The astronauts seem confident that such drastic action will not be necessary.

Other worries - not so great as they were - concern the possible loss of, or damage to, thermal tiles during the launch phase. Although some training has been done by astronauts on tile repairs, the first mission was not expected to carry the necessary repair kit. The vehicle will be flown at minimum loading and confidence in tile fixture has grown as a result of a densification process which increased the strength of the bonded surface in critical areas by a factor of two to four.•

Young and Crippen expect to remain in orbit for just over two days making checks of on-board systems in conjunction with Houston Mission Control where use will be made of the same consoles that were brought into operation for the Apollo Moon landings. However, the computers, video displays and communications systems have been updated and now permit operations to proceed with fewer flight controllers. The new system of communications includes more than 1,000 video formats each of which can present up to 250 parameters.

The astronauts have special tasks to perform in orbit besides monitoring their equipment. One involves opening and closing the Orbiter's huge cargo bay doors. Inside the doors are radiators which must be exposed in any flight lasting more than a few hours to disperse waste heat. Young and Crippen have been practicing EVA in the large water tank at the Johnson Space Center. If the cargo doors were to jam open, one of the astronauts would have to go out and close them, or the Orbiter's safe return could not be guaranteed.

The astronauts approach the re-entry procedure with the same equanimity. At entry interface the Orbiter will be moving at a speed of 28,500 km/h some 122 km above the Earth pitched up at 30° and descending at a shallow angle. Six minutes and 10 seconds later it will begin to pick up maximum heating. The period of maximum temperature must be endured for nine minutes, but the special silica insulation tiles that protect large areas of the spaceplane shed heat so readly that one side of the material would be cool enough to hold in bare hands while the other side is red hot.

At 28.18 after entry interface the pilot takes manual control heading towards the airstrip at Edwards Air Force Base, California. At 30.38 the undercarriage is lowered and the spaceplane touches down at 30.56. Although "Columbia" has been fitted with an automatic microwave landing system, this will not be used on the first few flights.

Astronauts Young and Crippen, who began training for the mission in January 1978, say they expect the flight to follow the work they have done on the moving base and fixed base simulators at Houston very closely. In the last month they have been putting in an eight hour week in each simulator in turn.

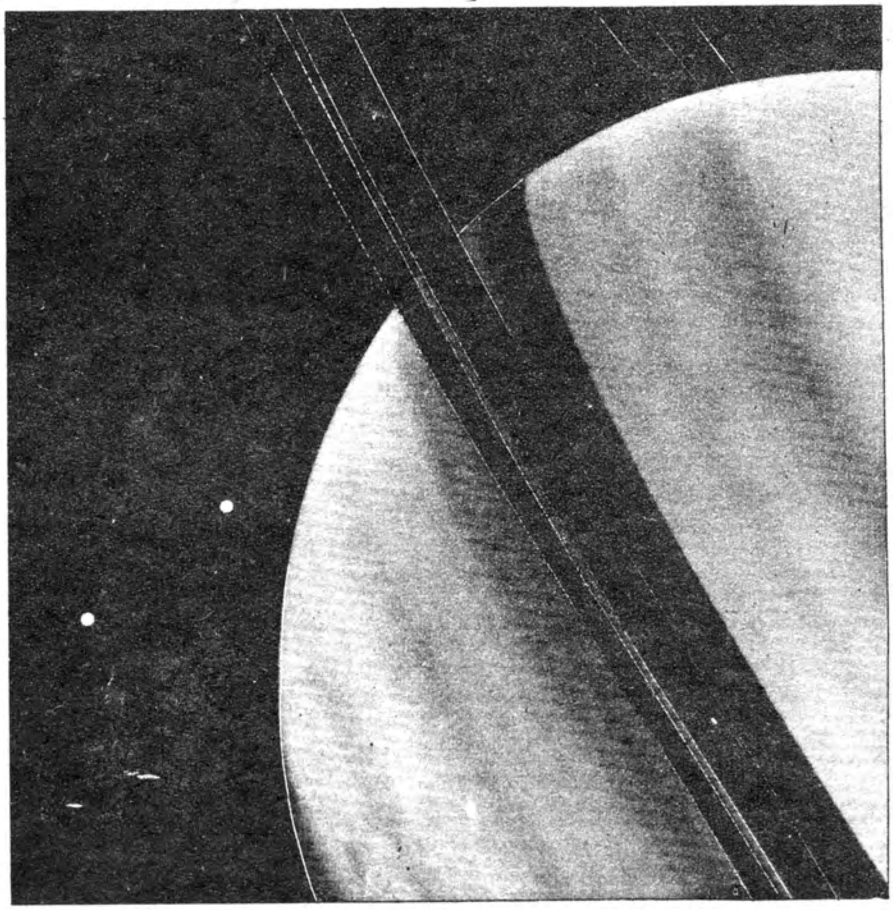
Target date for the start of formal operation of the Space Shuttle - following four orbital test flights - is the fifth flight of 'Columbia" in September 1982, when the first Tracking and Data Relay Satellite will be launched. The operational schedule during the first four years calls for 74 flights, of which 64 will be from the Kennedy Space Center and 10 from Vandenberg Air Force Base. The second Space Shuttle "Challenger" is scheduled to make its maiden flight in November 1982. "Discovery" and "Atlantis", the remaining shuttles, are expected to fly in December 1983 and March 1985 respectively.

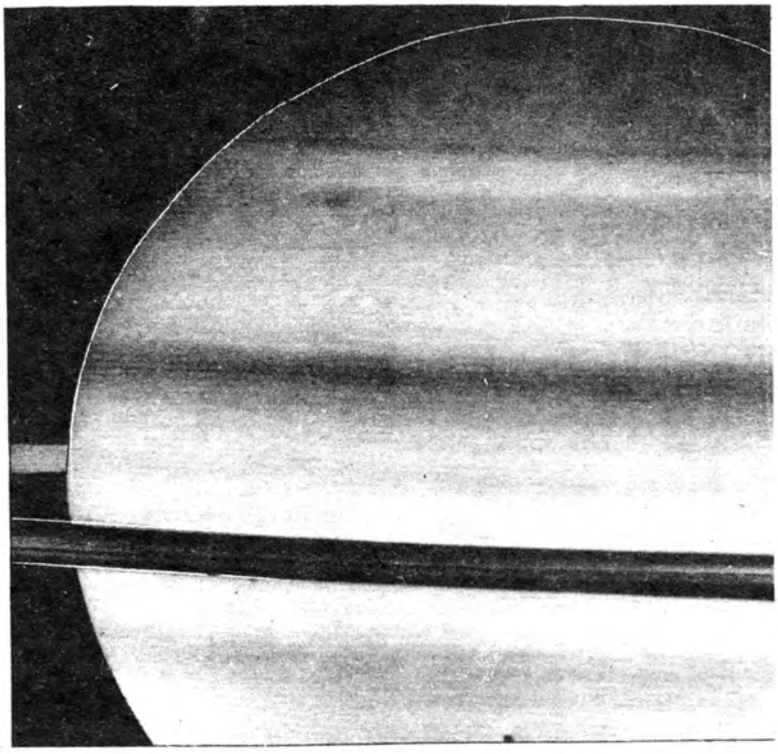
• *Some further work on tile closure was subsequently carried out on the pad.*

VISTAS OF SATURN

The close encounter of Voyager 1 with the planet Saturn last November has produced some of the finest space pictures it has been our privilege to examine. They range from vistas of Saturn and its remarkable ring system to revealing glimpses of some of the major moons. In publishing a selection of these pictures we offer our congratulations to the Voyager team at the Jet Propulsion Laboratory in Pasadena, California, on an outstanding technical achievement.

Saturn and two of its moons, Tethys *(above)* and Dione, were photographed by Voyager 1 on November 3, 1980, from 13 million km. The shadows of Saturn's three bright rings and Tethys are cast onto the cloud tops. The limb of the planet can be seen easily through the 3,500 km-wide Cassini Division, which separates ring A from ring B. The view through the much narrower Encke Division, near the outer edge of ring A is less clear. Beyond the Encke Division (at left) is the faintest of Saturn's three bright rings, the C ring or crepe ring barely visible against the planet.

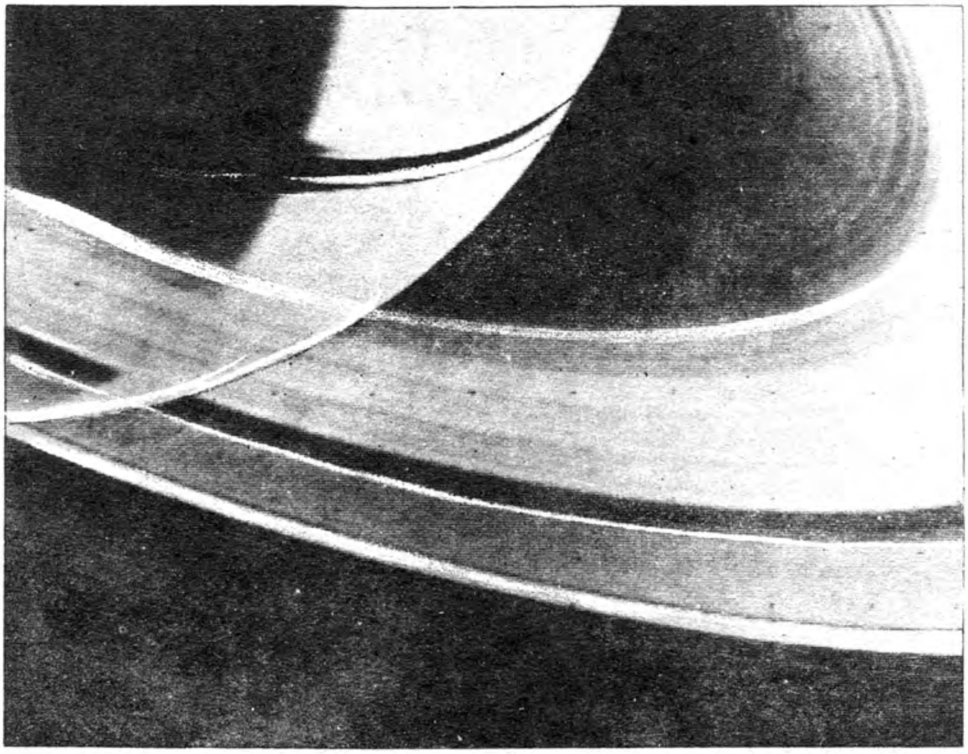




Left, low-level contrast between features in Saturn's cloud deck is shown in this composite photograph taken November 11, 1980 at a distance of 1,750,000 km. The small black shadow of the satellite Dione is seen near the bottom of the photograph: above the shadow is a barely visible bright spot. The brown spot in the northern hemisphere (centre, left) and the bright oval below it had been observed by Voyager for several weeks. Wind speeds in this latitudinal area are as high as 60 metres per second, so distances between these features increase rapidly.

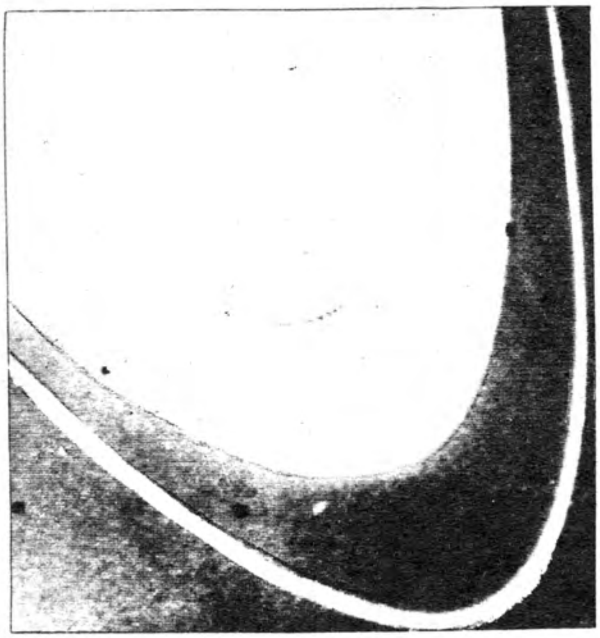
All pictures Jet Propulsion Laboratory, Pasadena, California.

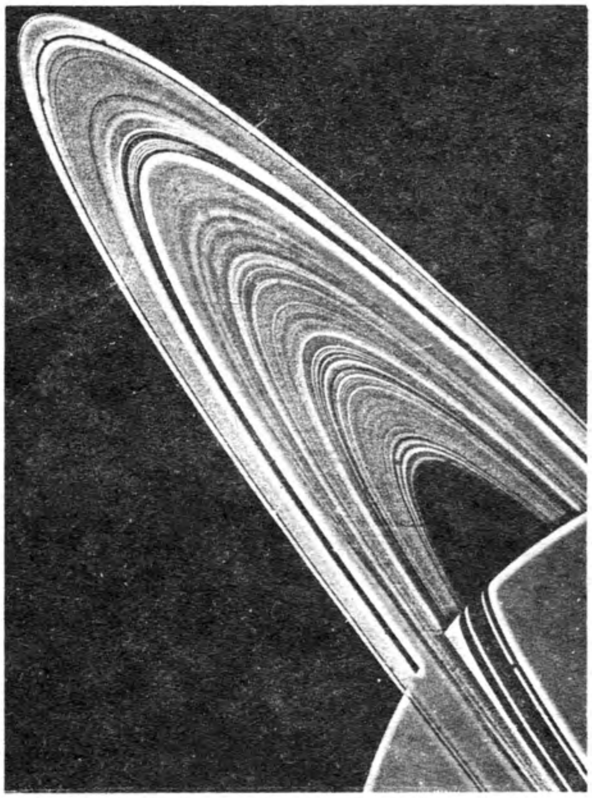
"We learned more about Saturn in one week than in the entire span of human history," said Dr. Bradford Smith of the University of Arizona, leader of the Voyager imaging team. At the same time, the data radioed back to earth by Voyager raised almost as many questions as it answered about the giant planet, its rings and its moons. The spacecraft photographed six new Saturian moons, some that had never been seen before, and some that had been reported as moons but not confirmed. We shall be reporting on the more detailed findings in future issues.



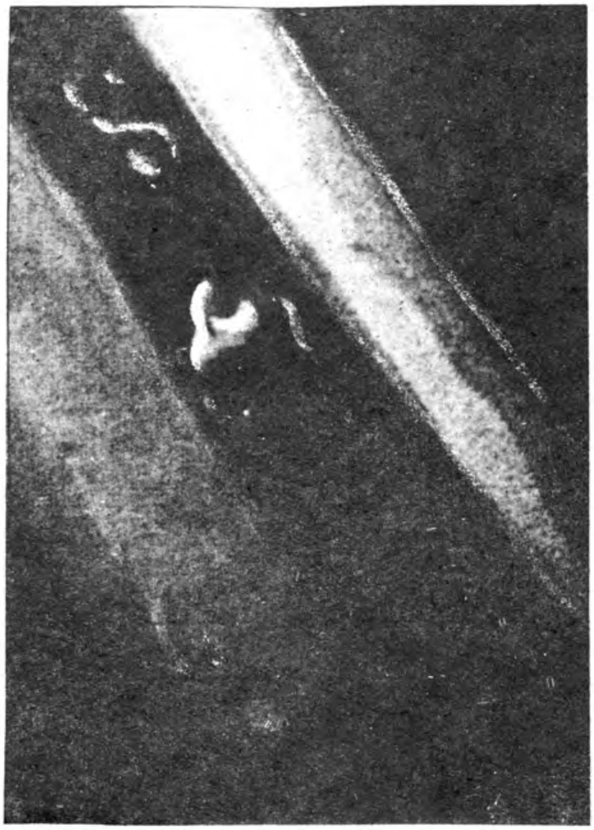
Left, the crescent of Saturn, the planet's rings and their shadows are seen in this Voyager 1 image taken November 13, 1980 at a distance of 1,500,000 km as the spacecraft began to leave the Saturn system. The bright limb of Saturn is clearly visible through the A, B, and C rings. The dark band cutting through the crescent is the shadow of the rings. This image was over-exposed to bring out detail in the rings, so the crescent appears artificially brighter.

Below, Voyager 1 found a 15th moon orbiting Saturn, visible near the bottom of this picture taken on November 6, 1980, when the spacecraft was still 8 million km from Saturn. Voyager imaging team scientists discovered the moon November 7, 1980, in the first of several programmed searches for new satellites of Saturn. The unique location of the 15th satellite, just 800 km outside the outer edge of the A-ring, is especially significant in that this small body, approximately 100 km in diameter, may be responsible for defining the outer edge of Saturn's bright ring system. The orbital period of the new satellite is approximately 14 hours, 20 minutes, the shortest orbit of any of Saturn's known satellites. The very narrow F-ring, approximately 4,000 km outside the outer edge of the A-ring, is seen prominently in this picture.

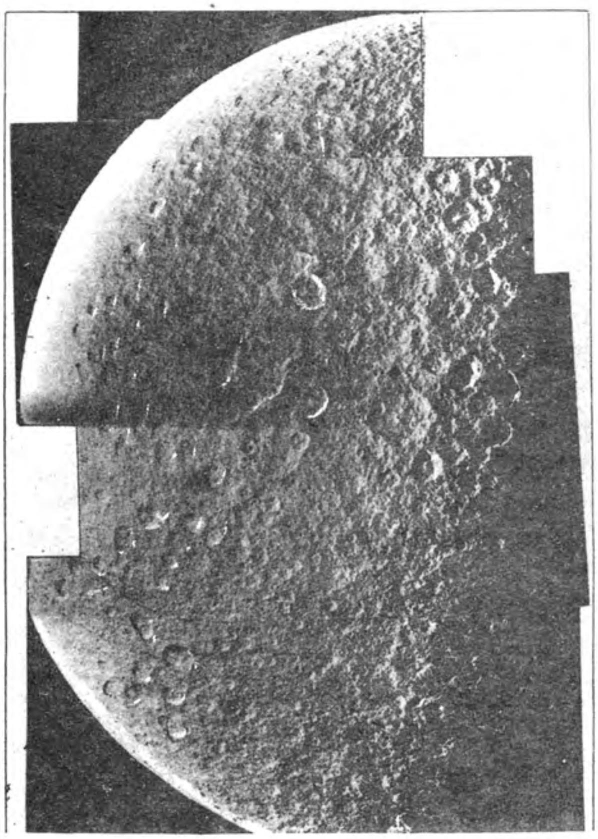




Above, this computer-assembled two-image mosaic of Saturn's rings, taken by Voyager 1 on November 6, 1980 at a range of 8 million km, shows approximately 95 individual concentric features in the rings. The ring structure, once thought to be produced by the gravitational interaction between Saturn's satellites and the orbit of ring particles, has now been found to be too complex for this explanation alone. The 14th satellite of Saturn, discovered by Voyager 1, is seen (upper left) just inside the narrow F-ring, which is less than 150 km wide.

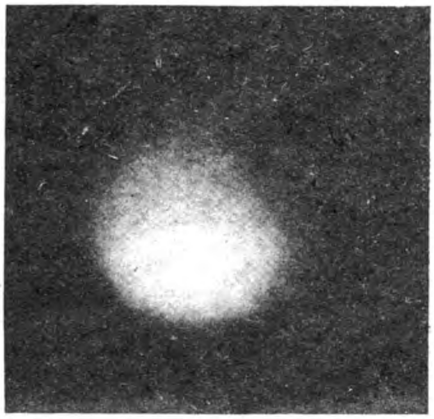


Above, this image of the northern hemisphere of Saturn taken on November 5, 1980 at a range of 9 million km shows a variety of features in Saturn's clouds. Small-scale convective cloud features are visible in the dark belt (centre); an isolated convective cloud with a dark ring is seen in the lighter zone, and a longitudinal wave is visible in the brighter zone (right of centre belt). The smallest features visible in this photograph are 175 km across.

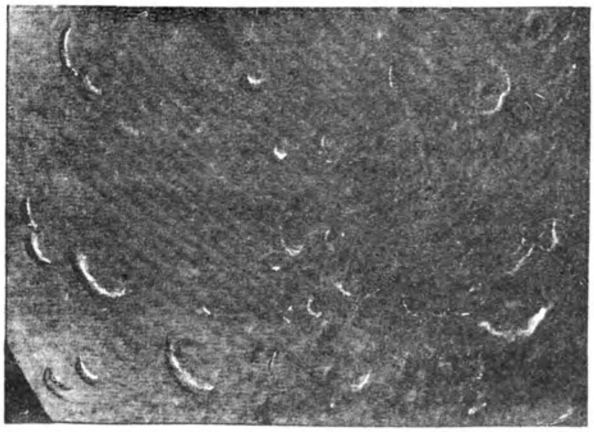


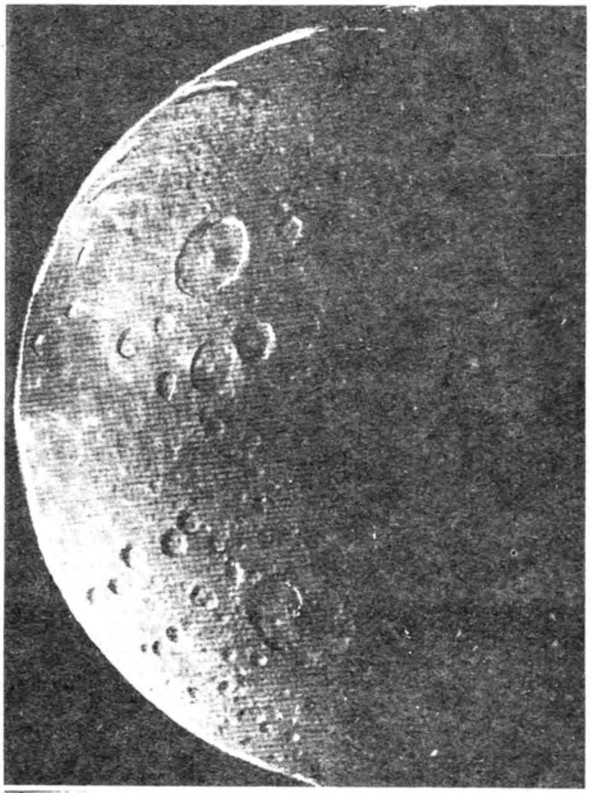
Above, craters stand shoulder-to-shoulder on the surface of Saturn's satellite Rhea, seen in this Voyager 1 mosaic of the highest-resolution pictures of the north polar region of the moon. Rhea is 2,400 km in diameter and is the most heavily cratered of the moons of Saturn. The largest crater, made by the impact of cosmic debris, is about 300 km in diameter. Many craters have central peaks formed by the rebound of the floor after the explosive formation of the crater.

Below, Titan, the largest of Saturn's 15 known satellites, shows little more than the upper layers of clouds covering the moon in this picture taken on November 4 1980 at a range of 12 million km. The orange coloured haze, believed to be composed of photochemically produced hydrocarbons, hides Titan's solid surface from the Voyager cameras. Some weak shadings in the clouds are becoming visible. However note that the satellite's southern (lower) hemisphere is brighter than the northern. It is not known whether these subtle shadings are on the surface or are due to clouds below a high haze layer.

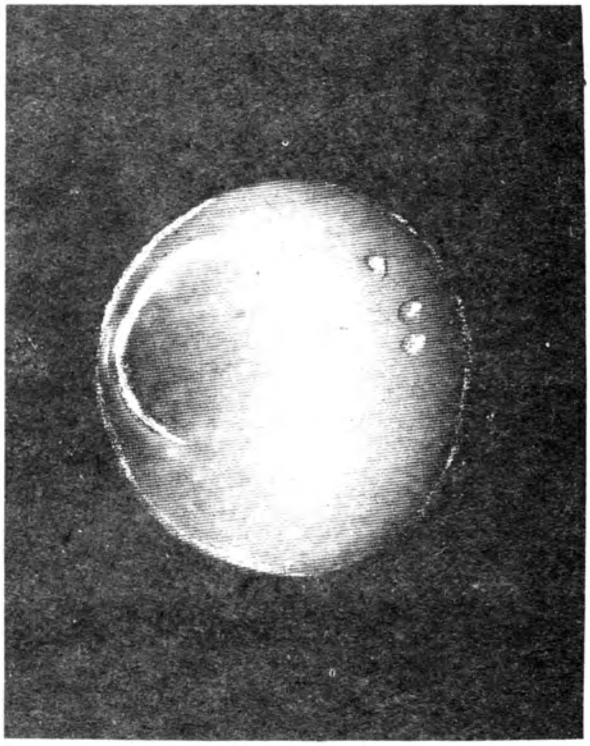


Below, Voyager 1 took this high-resolution image of Rhea just before the spacecraft's closest approach to the Saturnian moon on 12 November 1980 from a range of 128,000 km. The area shown is one of the most heavily cratered on Rhea, and indicates an ancient surface dating back to the period immediately following the formation of the planets some 4,500 million years ago. The photograph shows surface features 2.5 km in diameter, similar to a view of Earth's Moon through a telescope. White areas on the edges of several of the craters in the upper right corner are probably fresh ice exposed on steep slopes or possibly deposited by volatiles leaking from fractured regions.



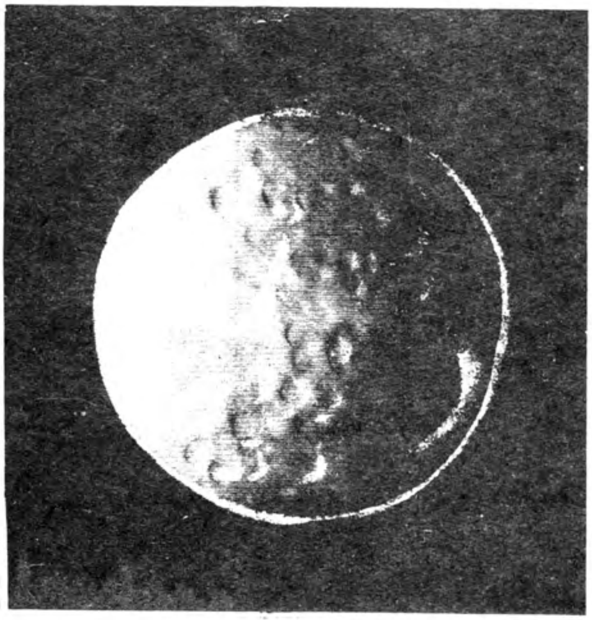


Above, many impact craters - the record of the collision of cosmic debris - are shown in this mosaic of the moon Dione. The largest crater is less than 100 km in diameter and shows a well-developed central peak. Bright rays represent material ejected from other impact craters. Sinuous valleys probably formed by faults break the moon's icy crust. Images in this mosaic were taken from a range of 162,000 km on November 12.

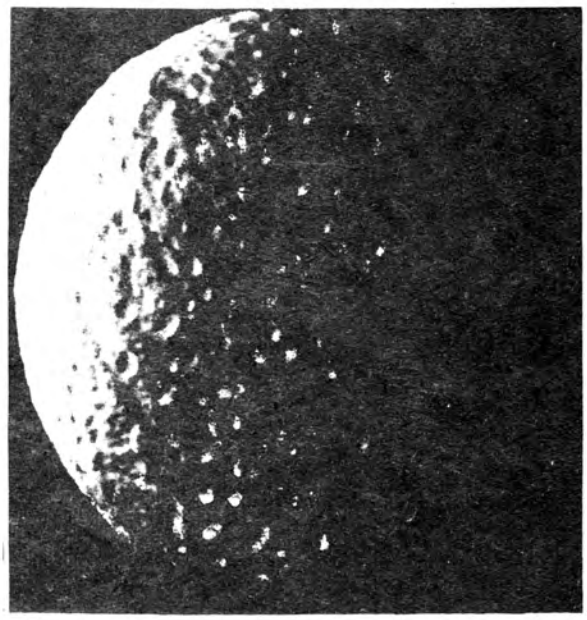


Above, Saturn's satellite Dione is seen in transit 377,000 km above the clouds of Saturn in this picture made from images taken on November 11. The difference in character between the trailing hemisphere (left) and the leading hemisphere of the moon is apparent. The trailing hemisphere contains relatively dark material criss-crossed by wispy light streaks. The leading hemisphere shows a relatively uniform surface with many impact craters. The cause of the difference between the two sides of Dione is one of the subjects of continuing study.

Below, the cratered surface of the moon Mimas is seen in this image taken by Voyager 1 from a distance of 425,000 km. Impact craters made by the infall of cosmic debris are shown; the largest is more than 100 km in diameter and displays a prominent central peak. Smaller craters are abundant and indicate that Mimas has an ancient surface.



Below, coming closer the spacecraft reveals more detail of the heavily cratered surface of Mimas which contains a record of the bombardment which occurred throughout the Solar System in its early history some 4,000 million years ago. This picture, taken from a distance of 129,000 km, shows craters approximately 185 km across.



A BRIEF HISTORY OF THE VOYAGER PROJECT - Part 2

By J. E. Davies
Continued from February issue

Introduction

In a preceding article the development of the Voyager project was described culminating in the launch of the first spacecraft, VGR77-3. Since this vehicle was placed on a slower trajectory than its sister ship and would be overtaken early in the mission, VGR77-3 was named Voyager 2 immediately after launch. With the exception of a brief hold five minutes before launch the countdown for Voyager 2 had proceeded smoothly and without incident; however several problems were to become apparent during the first few hours of the flight.

Launch Day Problems

Early in the launch sequence, while the Titan stage was still firing, what appeared to be a fault was detected in the Attitude and Articulation Control System (AACS) of the spacecraft. The AACS has three gyroscopes, mounted at right angles to each other, which are used to monitor the attitude of the spacecraft and any two are adequate for normal operation.

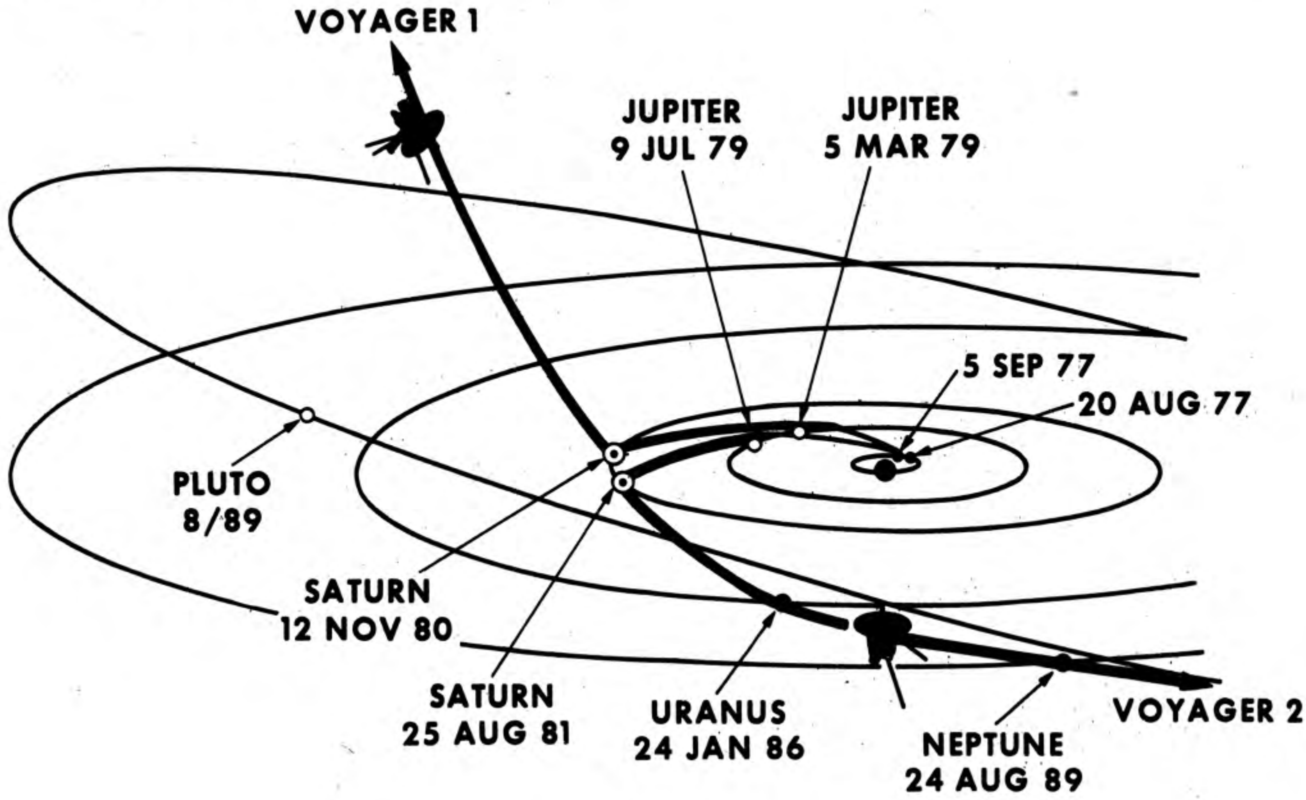
During the launch phase gyros B (roll and pitch) and C (pitch and yaw) were active and the onboard computer switched from gyro B to gyro A (pitch and yaw) when a failure was indicated. This was followed by a switch to gyros A and B when the apparent fault continued, suggesting that the problem lay with the pitch and yaw gyro, gyro C. As part of its in-built fail-safe routines the spacecraft switched over to its alternative AACS processor forcing ground controllers to check the contents of the AACS memory and determine that the commands for acquisition of the star Canopus were intact. Canopus acquisition was planned for the following day but the spacecraft was instructed to locate the Sun only, allowing it to be stabilised in two axes and this was achieved at 4.00.30 EDT The search had taken three and a half hours, considerably longer than the planned five minutes.

Concern was also felt that the science boom had failed to deploy since a microswitch, which opens as the boom reaches within 0.05 degrees of normal deployment, appeared to have remained closed. Twelve hours after launch one of the boom instruments, the plasma science instrument, was activated and measurements relative to the direction of the solar wind and a known axis indicated that the boom was within two degrees of the correct position. Most of the remaining instruments were turned on in the next few hours and all started to return measurements indicating that they were in good condition. The remainder of the antennae and booms deployed normally.

Although most of the problems encountered during the launch now appeared to be under control there was an unexplained pitch and yaw disturbance 18 hours into the flight and mission controllers immediately set about investigating this event. There was a similar occurrence a few days later at 11.25 PDT on 25 August. The possibility that these anomalies were due to a collision between the spacecraft and the discarded propulsion module was considered and ruled out when it was confirmed that it was no longer in the vicinity of Voyager 2.

On 24 August the attitude control system acquired the star Canopus after a series of scans about the roll axis thus completing the three-axis celestial stabilisation. As Voyager 2

Mission Plan. After its flyby of the Saturnian system in November 1980, Voyager 1 was diverted on an escape trajectory from the Solar System which carries it above the ecliptic plane. Voyager 2 will reach Saturn next August and then has the opportunity to continue to encounters with the planets Uranus and Neptune.
JPL



receded from Earth a series of photographs were taken to determine precisely the orientation of the science boom and from these it was calculated that the boom was deployed to within 0.06 degrees of the locked position. Two days later an attempt to fully deploy the boom was aborted by an error within the AACS and the spacecraft automatically returned to Canopus lock. It had been hoped that by simultaneously pitching the spacecraft and jettisoning the dust cover for the infrared interferometer spectrometer (IRIS) with its small explosive charges, enough of a jolt would be provided to fully open the boom hinge and allow the locking pin to fall into place. The cover was however jettisoned successfully a little later in the mission.

The first trajectory correction and the X-band radio transmitter calibrations were deferred because of the more immediate needs of the spacecraft and the forthcoming launch of its sister ship, but by 2 September all of the scientific instruments had been switched on. Later that day Voyager 2 was "put to bed" in its interplanetary cruise mode to allow flight controllers to concentrate their efforts on the launch of the second spacecraft, planned for 5 September.

As soon as the problem with the science boom of Voyager 2 was detected a decision was made to de-encapsulate VGR77-2 for inspection of the boom deployment mechanism and microswitch operation. This was carried out in the Spacecraft Assembly and Encapsulation Facility No 1 at Cape Canaveral. To ensure correct deployment, engineers installed five coiled springs on the boom and the spacecraft was re-encapsulated on 29 August.

After mating with the Centaur upper stage on 31 August VGR77-2 was successfully launched at 8.56.01 a.m. EDT from complex 41 of the Air Force Eastern Test Range, Cape Canaveral, after a perfect countdown. Although the Titan second stage shut down a little early a longer burn by the Centaur stage corrected the anomaly and Voyager 1 was placed on course by a second planned Centaur burn and a brief boost from the spacecraft propulsion module. Voyager 1 did not experience any of the problems encountered by its twin and all of the booms and antennae deployed exactly as planned.

During the first 14 days of its journey Voyager 1 activated all of its scientific instruments and carried out a series of calibrations of the on board communication systems. These were followed by two trajectory correction burns which although carried out without incident did not produce the required velocity increment. The reason for this was believed to be exhaust gases impinging on spacecraft structure supports but no plans for extra corrections were made. The difference of approximately 2.5m.sec-1 was made up during the next manoeuvre. On completion of these two burns Voyager 1 was also commanded into its interplanetary cruise mode.

Interplanetary Cruise

As the two Voyagers pursued their 18 month journey to Jupiter mission operations settled into a routine punctuated by minor difficulties and an occasional crisis. Many of these events are chronicled below, with occasional details of distance from Earth, heliocentric velocity and one-way communication time.

On 23 September 1977, Voyager 2 suffered a failure of its Flight Data Subsystem (FDS) circuitry which caused the loss of 15 of the 243 engineering measurements, but this did not prevent a successful course correction being carried out a few weeks later on 11 October. Voyager 1 also made a small correction in October, on the 29th, which removed the residual error from the first burn.

On 31 October controllers instructed Voyager 2 to rotate and acquire the star Deneb as a celestial reference point. Deneb lies on the opposite side of the sky from the usual reference star Canopus and this manoeuvre effectively placed the spacecraft "upside down". The reason for this unusual step was an attempt to reduce the effect of the solar wind which had been continually altering the attitude of the spacecraft and causing an increase in the rate of propellant used as the AACS strove to correct for the drift. Studies by the Voyager engineering teams indicated that this fuel depletion would not prejudice the mission and that a 9 kg margin existed even for the possible Uranus option.

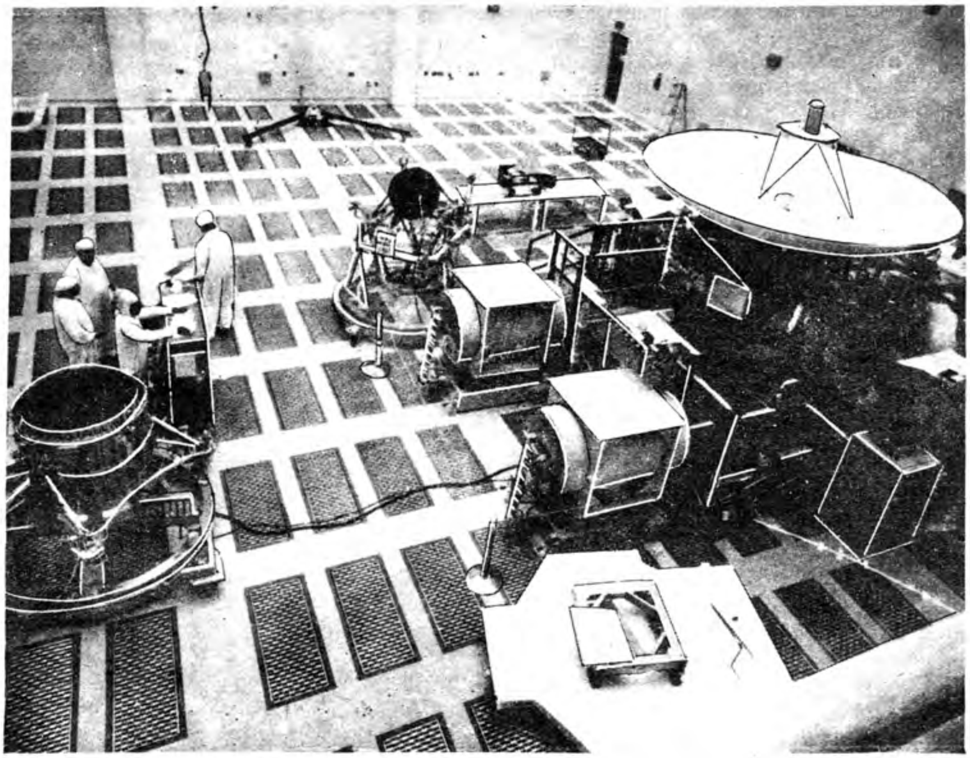
Apart from minor problems including a stuck filter wheel on the photo polarimeter Voyager 1 continued in good health and on 15 December it overtook the slower Voyager 2 spacecraft. It would continue to pull ahead and its lead would have increased to four months at the time of Jupiter encounter. The 24 December mission status bulletin announced that during camera calibrations an object 30m long composed of nine distinct images trailed by a larger rectangular object had been detected. Evaluation of radio transmissions revealed a pulsed repetitive signal of "HO HO HO and a Merry Christmas to All".

On 5 January 1978 Voyager 1 was 177 million kilometers from Earth travelling at 27km-sec; the one-way communication time was nine minutes and 49 seconds. The figures for Voyager 2 were 174 million km, 26km-sec and 9 minutes 40 seconds respectively.

Throughout January and February the two spacecraft continued to take scientific measurements during the cruise phase including regular 360 degree scans of the whole sky and occasional camera calibrations. Work was continued to determine the reason for a failure of one such scan which terminated early on 17 February. A problem with the gyros of Voyager 1 was believed to be the cause. On 21 February Voyager 1 was 322 million km from Earth and had slowed to 23km-sec. Voyager 2 was 9 million km nearer to home, travelling at 22km-sec, and the one-way communication time had increased to over 17 minutes. It was during a camera calibration scan on 21 February that the scan platform on Voyager 1 ground to a halt. It took three weeks to free the platform fully and on 23 March the scan platform was positioned in such a way that should it fail again it would be in the most favourable position for the encounter with Jupiter.

In April a series of communications problems developed with Voyager 2 which seriously endangered the mission. At the beginning of the month the main radio receiver apparently failed and after a period of seven days had passed without any commands being received the back up receiver was selected by the on-board computer. Attempts to contact the spacecraft on the back up receiver failed, probably due to a failed tracking loop capaciter. After twelve hours the spacecraft, following its protection routine, switched back to the main receiver. This switch over appeared to reactivate the receiver and for 30 minutes several commands were accepted by the spacecraft, reseting the seven-day timer in the main radio system. Then the main receiver suffered an excessive current surge from an unknown source and the receiver fuses blew. This left the spacecraft still switched to the now useless main radio and out of contact with Earth for a further period of seven days. An additional problem was that due to the failed tracking loop in the reserve receiver the spacecraft would be unable to follow the changes in frequency in up-linked messages caused by the Earth's rotation.

On 13 April the back-up receiver switched back into service and contact with Voyager 2 was re-established. In an impressive feat of improvisation engineers had determined the frequency on which the spacecraft was listening and computed the changing frequency on which to transmit commands. Various steps were then taken to prevent changes in the receiver's temperature which could alter its frequency characteristics and to boost the transmitters on the spacecraft to full power in an attempt to ease the tracking requirements. After a critical phase hopes rose at mission control that all the objectives of the flight could still be achieved. On 26 April the on-board computer of Voyager 2 was successfully updated



One of the Voyager spacecraft in a vertical flow clean room. To the far left is the structure to house the TE 364-4 solid rocket kick stage and includes the 100 lb (45.3 kg) and 5 lb (2.2 kg) thrust vector control rockets. The black sphere in the upper centre is the hydrazine fuel tank and the plumbing and thrusters for attitude control and trajectory correction manoeuvres are mounted on a support fixture. The drum shaped containers are flux tanks to shield the magnetometers for test purposes. The balance of the spacecraft is to the left in a test configuration.

NASA, JPL

using new techniques which had been developed to communicate with the spacecraft through its remaining, crippled receiver. The transmitted signal was being programmed to match the receiver frequency to within 50Hz; it was indeed fortunate that the 64 metre antennae of the Deep Space Network already had this capability.

As mission operations again settled into a routine the engineers at Pasadena continued to refine their control techniques and made some minor changes to the AACS. One of these was to modify the computer software to allow the spacecraft to be turned at a very slow rate without the automatic drift compensation attempting to stop the motion. A second was to compensate for attitude changes or changes in rate caused by the movement of the digital tape recorder. The changes, although small, were enough to cause smearing in the imaging and the AACS was instructed to sense when the recorder started, stopped or changed direction and to pulse the control jets to offset the torque.

During September of 1978 tests were conducted to determine if the radio astronomy experiment of Voyager 2 could be used "in reverse" to receive ground commands should the remaining receiver fail.The radio telescope at Stanford University, California, transmitted signals on a frequency of 46.72 MHz and it was concluded that the spacecraft could indeed receive this frequency and that the signal-to-noise ratio was acceptable. Since major changes in the spacecraft's on-board computer programs would be required if such a technique was invoked further studies of this possibility were put under way.

On October 25 Voyager 1 was about 675 million km from Earth and travelling with a heliocentric velocity of 14.9 km-sec. One way radio communication time was now 37 minutes and 36 seconds, but of more concern to mission controllers was that the spacecraft had safely traversed the asteroid belt and encounter operations with Jupiter were only 78 days away. For this reason a series of tests to ensure that both spacecraft and ground systems were ready for encounter were in progress and proceeding satisfactorily. Sister ship Voyager 2 was just leaving the asteroid belt 637 million km from Earth and still 6 months from the beginning of its encounter operations.

The final few weeks of Voyager 1's cruise to Jupiter was a busy period for the engineers at Pasadena with a series of crucial calibrations and tests to review the project's readiness for the Jupiter encounter. On 10 and 11 December a series of photographs covering two rotations of the giant planet were recorded so that identification of features of special interest could be made. Also on the 11th the Sun sensors, high gain antenna and scan platform pointing and imaging optics were calibrated. This was followed by a 39 hour Near Encounter test, essentially a dry run of the operations planned to occur around the time of closest approach; then as Christmas drew near a two week period of relative quiet followed to allow personnel a chance to rest before Voyager 1 entered its observatory phase on 4 January of the new year.

Voyager 1 Observatory Phase

On 4 January 1979 Voyager 1 was sixty million kilometres and sixty days away from Jupiter and detailed long range observations of Jupiter were just beginning. The observatory phase of the mission was designed to provide a time history of scientifically important phenomena on the giant planet. Most of the material recorded during this phase was of a repetitive nature to provide a data base for all the ensuing data.

After a series of calibrations made over two days, the long range imaging experiments began. Every two hours, a period representing one fifth of a rotation, a series of four narrow angle photographs were taken, each in a different colour. The series of pictures were part of a study of the large scale dynamic properties of the turbulent atmosphere and from them JPL scientists were able to produce a motion picture covering many revolutions of Jupiter. Individual images were then examined to identify features of particular interest to allow them to be targeted and examined in more detail during the closest approach.

Meanwhile the remaining optical instruments were far from quiet. The ultraviolet spectrometer rastered the Jovian system eight times a day, mapping the distribution of UV emissions, and about one hundred infrared spectra were recorded every day. The photopolarimeter was also in use as it scanned for the edge of Io's sodium cloud. Other instruments probed the

electromagnetic and particular environment searching for the interaction between the solar wind and the planet's magnetosphere and listening out for bursts of radio emissions.

Each day's scans provided enough material to nearly fill eight tracks on the 328 metre length tapes used by the on-board digital tape recorder. The tape was played back to Earth, via the 64 metre antenna of the DSN, daily taking approximately three hours every time.

As the spacecraft closed in with its target the detail evident in the pictures began to increase and by the end of January the circulation patterns, especially around the Great Red Spot, were beginning to appear.

Daily system scans, infrared mapping and ultaviolet searches continued as the observatory phase drew to a close during the beginning of February. For a four day period beginning 30 January a 100 hour intensive imaging experiment took place with photographs being recorded every 96 seconds and transmitted to Earth in realtime via the high data rate (115,200 bits per second) X-band. The use of the X-band transmitter required continuous coverage from the three 64 metre antennae of the DSN and so contact with Voyager 2 and other NASA deep space probes was maintained using other smaller antennae. The termination of this period of intensive imaging on 3 February effectively marked the end of the inbound observatory phase of Voyager 1 since at its end the spacecraft was so near to its target that the planet filled most of the image from the narrow angle camera and mosaics would soon be necessary to ensure full coverage of the planet.

During this period of intense activity for Voyager 1 the trailing Voyager 2 had been following a quiet routine of tests and calibrations at cruise level. Voyager 2 would have its moment in a few months time. For the moment it was almost forgotten as the world turned its eyes to Voyager 1 and to Jupiter, the leader of the Gods, as it had never been seen before.

Details of the close encounters with Jupiter and the long journey of the Voyagers to Saturn will be given in future articles. The author would like to express sincere thanks to the staff of the Voyager Project for their help in providing material for these articles.

To be continued

SALYUT 6 MISSION REPORT - Part 6

By Neville Kidger
Continued from February 1981 issue

Progress 10 in Flight

Before the launch of the tenth Progress cargo spacecraft the Dniepers (Popov and Ryumin) carried out a repair to one of the two redundant "Kaskad" attitude control subsystems of the Salyut 6 station. The operation consumed a large amount of crew time, to evaluate the repair, and propellant for checks.

When Progress 10 was launched from Baikonur, at 0441 (all times GMT) on 29 June, 30% of the dry cargoes it carried had been requested by the cosmonauts. From the initial orbit of 191 × 281 km; period 88.9 minutes; inclination 51.6°, the cargo spacecraft was manoeuvred, over the next two days, to a successful automatic docking with Salyut 6/Soyuz 36 which occurred at 0553 on 1 July. As usual, after opening the internal hatches to the cargo spacecraft, the first item the Dniepers unloaded was a 3 kg package containing letters from their families and new periodicals.

The Dniepers made light work of unloading the dry cargoes the spacecraft delivered and routinely installed new equipment into the systems to replace ailing or worn-out units. Amongst the routine cargoes were several items new to the station including a US-made Polaroid instant camera and film, a new 25 cm colour TV for use on the Earth-Orbit TV link (the previous TV was B/W) and cassettes of new pop music for the Elektronika tape recorder.

Amongst the foodstuffs delivered were new specimens of onion, dill, peas, parsley, cucumber, radish and even some canned fish. The fresh foods, and also some new flower seeds, were planted in the hydroponic garden to mature and provide data for the biological experiments. Generally speaking it was noted that flowers had a tendency to wilt and die before reaching maturity in the installation but vegetables seemed to fare much better. This prompted the Soviet planners to concentrate their attention on the study of root vegetables which would, on longer flights to the planets, be a source of fresh food.

• *References and acknowledgements as Part 1*

For the continuation of their scientific experiments Progress 10 delivered new intensifiers for the BST-1M and a device to rectify a fault in the Bulgarian-made Duga instrument which was presenting an inversed image. Finally water and fuel were pumped into the Salyut's respective tanks.

At 2221 on 17 July Progress 10, its SKDU having been used earlier to put Salyut 6/Soyuz 36 into a 91.2 minute orbit with an altitude of 328 x 355 km (slightly lower than normal for a rendezvous with a ferry ship), was undocked. At 0147 on 19 July the SKDU was activated for the final time to send Progress 10 to destruction in the dense layers of the atmosphere away from the shipping lanes.

The Cosmic Olympians

When Soyuz T-2 cosmonaut Malyshev and Aksenov returned to Earth on 9 June they reported that the Dniepers were working enthusiastically and were seemingly gaining in their capacity for work. The cosmonauts might well have noted that Popov and Ryumin were also in very good spirits as they demonstrated during the 22nd Olympic Games which, accompanied with tremendous fanfare, were held in Moscow between 18 July and 3 August. During the opening ceremony the Dniepers formally read out, *via* TV, a pre-prepared statement to the Lenin Stadium in Moscow. Their serious official attitude contrasted sharply with their less public statements to FCC controllers. When asked what they would be doing during the games Popov commented: "not competing! After all we are able to go once around the world in 90 minutes, no athlete could match that!" During the period of the games the Dniepers were able to see all the major events *via* the Earth-Orbit TV link. They were, of course, true patriots cheering on Soviet victories and at one stage expressing their "extreme dissatisfaction" with the Soviet basketball team who had been eliminated in the semi-finals of the event. (It will be recalled that during the Salyut 3/Soyuz 14 flight in 1974 controllers kept cosmonaut Pavel Popovitch extra busy to avoid having him listen to the World Cup Soccer match between Brazil and Poland).

New International Crew

On 23 July the launch window opened for another 8 day Interkosmos flight and, as expected, the Soviets launched another crew to the station. There had been some debate before the flight by Salyut observers as to the nationality of the cosmonaut-researcher of the next Interkosmos flight. Next in line according to the Soviets in 1979 was a Cuban but by 1980 a Vietnamese cosmonaut was being tipped as the next Interkosmonaut. Expectations that the CR would be a Cuban were heightened in early July when the Cuban news agency announced that the Dniepers were preparing the station for a new crew to join them and describing, in general terms, the experimental programme mapped out for the Soviet/Cuban crew. When the flight occurred, however, the companion to the Soviet commander was a citizen of the Socialist Republic of Vietnam (SRV).

The first notice that Vietnam was to have a cosmonaut came (unintentionally?) from an interview with Vladimir Lyakhov on Radio Moscow broadcast on the day of his launch, 25 February 1979. In his pre-flight interview Lyakhov stated that crews with representatives from Bulgaria, Hungary, Cuba, Mongolia, *Vietnam* and others (*sic*) were preparing for future flights. First official statement that Vietnamese pilots were in training occurred on 18 May 1979 when TASS said that in accordance with their participation in the Interkosmos programme, of which she is a signatory, Vietnam had sent 2 pilots to Moscow for spaceflight training.

The two crews preparing for the Soviet/Vietnamese flight were: Prime crew of Viktor Gorbatko (USSR) and Lt-Col Pham Tuan (SRV), a 33 year old pilot who was already a hero of the SRV for his feat of shooting down an American B-52 bomber in 1972, during the Vietnamese War, with his MiG fighter (a claim which the Pentagon strongly denies, claiming that all the B-52 losses were made to SAM batteries and not to MiG jets). The reserve crew consisted of Valeri Bykovsky (USSR) and Bui Thanh Liem (SRV).

Victor Gorbatko (USSR) and Pham Tuan (Vietnam) pictured during a training session at the Gagarin Cosmonauts' Training Centre. *Novosti Press Agency*

Soyuz 37 in Orbit

Standing in the squares marked KK (Spaceship commander) and BI (Flight Engineer), as normal for all the pre-flight statements, facing the huge A-2 carrier rocket carrying Soyuz 37 under the shroud, the Soviet/Vietnamese cosmonauts Viktor Gorbatko and Pham Tuan made the usual round of thanks and dedications to all concerned with the flight at national and party level. It was about 2100 local time at Baikonur (1600 GMT) as the two men were taken to the Soyuz cabin. Pham Tuan carried with him a small engraving of Lenin carved by a Vietnamese artist and dedicated to the flight.

At 1833:03 (GMT) on 23 July Soyuz 37 was launched into the night sky beginning the sixth Interkosmos manned flight. Although it can be stated that politics may have played a part in the selection of an SRV cosmonaut for the flight during the period of the Olympic games, the same is not true for the actual timing of the flight. *Ballistics* dictated the Soyuz 37 launch date despite the spectacle of western journalists being asked to applaud the launch at the 24 July press conference of Games Organiser Popov who also delivered a lengthy oration on the meaning of the flight (to sports journalists?!).

In space Tuan reportedly suffered from headaches and loss of appetite during the first hours of the flight, symptoms not uncommon with rookie cosmonauts, but he soon recovered. Following the standard pattern Soyuz 37 rendesvoused with Salyut 6/Soyuz 36 the following night after about 24 hours of flight.

In preparation for the docking approach Ryumin, watching *via* TV, asked the Tereks (Gorbatko and Tuan's call sign) to activate their beacon lights on Soyuz 37 when 2 km from the station rather than at 100 m as planned. Ryumin required more data on their approach for the docking which would take place in darkness. The docking was accomplished without further incident at 2002 on 24 July. Three hours later the internal hatch was opened to the aft docking unit and the Tereks were welcomed aboard by the Dniepers with the usual warmth. Following their celebration supper and an exchange of telegrams with the Soviet and SRV leadership the Tereks began the first of 30 planned experiments. This was about 1 hour after they had entered the station. Both crews retired shortly afterwards because it was early morning Moscow Time. The four men were allowed to sleep an hour longer than planned before FCC woke them all at 1100 (now 25 July) to begin the planned series of experiments in earnest.

SRV Experiments

During their 7 days aboard Salyut the Tereks devoted much attention to the programme of Earth observations which, for the first time ever, would yield maps of Vietnam's geological, mineral, botanical and oceanographic features. From their height of 345 km the Tereks obtained photographs and spectral data of Vietnamese territory using the KATE-140 and MKF-6M cameras allowing specialists the opportunity to study:

- Tidal flooding and erosion on the Vietnamese coastal areas;
- Silting in the mouths of Vietnamese rivers to assess fish feeding habits and their effects;
- Hydrological features of the Mekong and Red River deltas and Central Plateau Region, and
- Effects on the Vietnamese countryside, plants and forests of the enormous amounts of defoliants and fire bombs, dropped during the Vietnam War, and develop effective methods to revive the soil.

In the BIOSPHERE V (for Vietnam) experiment the Spektr 15 instrument was used to obtain the spectral characteristics of certain regions of the Vietnamese countryside to assess their

biological productivity. Studying the planet visually Pham Tuan noted that the countries of South-East Asia, notably Laos, Thailand and Kampuchea, appeared very green and he was able easily to distinguish rivers and roads.

Atmospheric observations were conducted under the POLARISATION, TERMINATOR, REFRACTION and related experiments using the small GDR-made Pentakon 6M and Praktika EE2 hand-held SLR cameras. These experiments were described in the last part of the Mission Report.

Medical experiments saw the Tereks assess their own parameters with the instruments on board the station including the Czechoslovak Oxymeter, GDR Pneumotest, and the USSR Chibis suit with which the visitors also conducted detailed examinations of the Dniepers' cardiovascular state. Pham Tuan's breathing rate was measured during exercise on the veloergometer and his cerebral blood flow was also assessed.

In the field of technology the Tereks conducted the IMITATOR 2 experiment to determine the thermal profile of the Kristall 3 furnace after its long stay in space. The data would be used to assess the state of the unit and aid subsequent crews to obtain higher quality melts in it. In the HALONG experiment (named for a Vietnamese gulf) the Tereks obtained a gallium phosphide semiconductor crystal and a bismuth-antimony-telluride compound from the Kristall unit.

In the AZOLLA experiment the cosmonauts attempted to cultivate samples of the plant azolla which is a fast-growing, nitrogen-rich, water fern used as a fertiliser in the Vietnamese rice paddies. Specialists hope that, like the chlorella plant tested on Salyut before, the fern may lend itself to use in future space stations as part of a closed ecological system ensuring the proper circulation of chemicals in the atmosphere.

The crew re-photographed each of Salyut's 20 portholes with the Pentakon and Praktika cameras to determine their, by now, pronounced, degrading optical characteristics in the ILLUMINATOR experiment.

Return to Earth

On 28 July both crews participated in the customary press conference. Gorbatko noted that he was impressed by the size of Salyut when compared to the small Soyuz ferry. Part of the time during the Tereks final two days on the station was taken up transferring their seats from Soyuz 37 to Soyuz 36 in which they were to return. As usual the fresher Soyuz was to be left for the resident crew. On 30 July the results of their work on Salyut were stored in the Soyuz 36 descent cabin in preparation for the return to Earth the next day.

At 0700 on 31 July the crews checked the Salyut and Soyuz systems in preparation for the undocking. At 0852, following the farewell speeches seen on TV, the internal hatches were closed sealing Gorbatko and Tuan in Soyuz 36. At 1155 Soyuz 36 unlatched from Salyut's front docking unit and performed the separation burn.

During their final orbit before retrofire the Tereks were addressed by Granit (Vladimir Shatalov) *via* radio from FCC who informed them of the weather conditions at the landing site. He told them that there were few clouds, visibility was over 10 km and there was a slight south-westerly wind.

At 1425, on command from the tracking ship *Borovichi* in the South Atlantic, the Soyuz 36 SKDU was ignited for over 200 s to bring the spacecraft out of orbit. The Tereks made a soft landing at 1515 some 180 km SE of Dzhezkazgan. Newsmen were quickly on the scene to record the cosmonauts' traditional impromptu news conference next to the descent capsule. The Tereks thanked the workers, both in space and on the ground who had helped make the flight such a success.

Gorbatko and Tuan were pronounced to be in good health by the medical team and were flown from the landing site to Dzezkazgan and then to Baikonur for their debriefing reports. On 4 August the cosmonauts arrived in Zvezdny Gorodok for

The two Vietnamese pilots selected as cosmonauts: *left*, Bui Thanh Liem (who became the backup) and Pham Tuan (who flew into space with cosmonaut Gorbatko).

Theo Pirard

the first of their many press conferences. Finally, before departing for their tour of Vietnam, they were awarded medals for their flight in the Kremlin on 16 August

Experimental Work in Orbit

On 1 August, just over 24 hours after the Soyuz 36 touchdown, the Dniepers redocked Soyuz 37 to the front docking port of Salyut 6. The spaceship, with the cosmonauts aboard, was undocked from the rear docking unit at 1643 and backed away to an unspecified distance while Salyut rotated 180° and then redocked with the front unit.

Despite the speed of the redocking, suggesting that another manned flight was imminent, no more Soyuz or Progress spacecraft were launched throughout the August window. The reason was apparently to allow the cosmonauts to concentrate upon the series of important Earth observations and smelting experiments planned for completion before the launch of the next Interkosmos crew at the next window and their subsequent return to Earth during the same window (mid-October). The Soviets had earlier announced that the flight would not greatly exceed the 175 day flight in terms of length of time spent in space although the 6 month flight did allow for three Interkosmos flights to take place.

The reason for the lack of a Progress tanker became clear in mid September when the Soviets said that Salyut 6 still had about 2.5 tonnes of cargo aboard (more than when the Dniepers were launched). To have launched another Progress ship would have meant bringing more cargoes to a station already full to the brim with equipment. Refuelling was not a significant factor in the decision because the cosmonauts were leaving Salyut 6 in a gravity gradient stabilised mode, most of the time with the attitude thrusters deactivated to allow them to conduct a broad range of Earth observations and smelting experiments. The only times the thrusters were activated were during the sessions of photography with the MKF-6M and other cameras. The main targets for observations were the agricultural lands of the Soviet Central Asian Republics. August and September were traditionally the best months for observations of these areas because of a lack of the clouds which covered the areas during the earlier months.

Birthday Celebrations

During August both cosmonauts celebrated birthdays. Valery Ryumin's was the first, on 16 August. The occasion was notable because it was the second he had spent in space aboard Salyut

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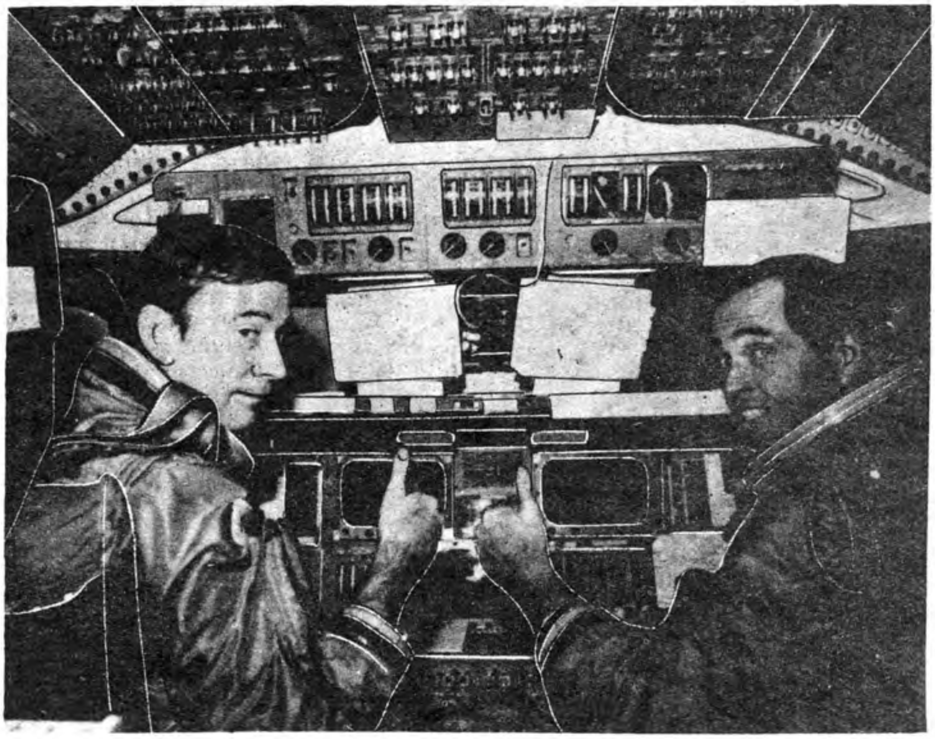

On the flight deck. Prime crew of the Space Shuttle "Columbia" (left) John Young, commander, and Robert Crippen go over their check lists during a power up mission simulation for the maiden flight. The two men began training for their exacting mission in January 1978. The launch will take place from Launch Complex 39A at KSC "no earlier than 17 March". If all goes well the flight will last just over two days ending with a landing at Edwards Air Force Base, California.

NASA

REDUCED-WEIGHT SHUTTLE TANK

The Marshall Space Flight Center plans to reduce the weight of the Space Shuttle's external propellant tank by 6,000 lb. (2,722 kg). This change promises to increase the Shuttle's payload-carrying capability by almost the same amount.

Marshall has amended its existing External Tank design and development contract with Martin Marietta Aerospace, Denver (Colorado) Division, to add more than $42.9 million to cover the weight reduction redesign and development efforts and to modify tooling to be used in future production.

Martin Marietta is already building nine tanks, including three test articles and six tanks, to be used in the Shuttle orbital flight test series. These are not affected. The design change will apply to tanks to be built under a separate contract, which calls for the company to begin the initial phase of full-scale External Tank production to support operational launches. The first lightweight External Tank is expected to be delivered in the summer of 1982.

SPACE SLED EXPERIMENTS

An event of considerable import to the Space Transportation System occurred during 1980. The European Space Agency decided not to fly the Space Sled Vestibular Experiment on Spacelab 1. The Space Sled was deleted as the result of an increase in the payload weight, primarily due to instruments. The removal of the Space Sled will permit Spacelab to remain within its allocated weight. The Space Sled has been tentatively assigned to the dedicated Life Sciences, Spacelab 4, scheduled for launch in April of 1984. This new flight assignment is under consideration for the German D-1 mission as a potential alternative.

However, the Space Sled static experiments will be performed. According to Dr. Ken Money of the Defence and Civil Institute of Environmental Medicine in Toronto, Ontario, ". . . we had eight experiments on SL-1 and the sled was necessary for four of them, so we have four remaining. We hope the sled will fly on SL-4 and if it does our other four experiments will be done then."

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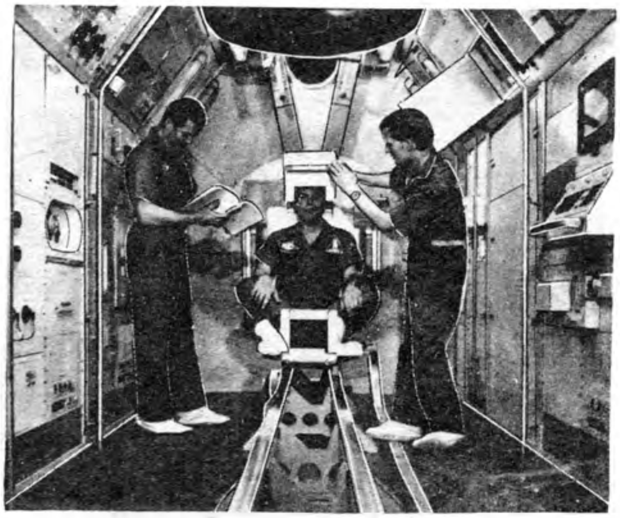
6. Unlike the year before, when he had expected to celebrate it on the Earth but had to celebrate in space following the unscheduled EVA to free the KRT-10 antenna (see part 2) and their subsequent delayed return to Earth, Ryumin had expected to be in space for this birthday from the start of the flight.

To mark the occasion FCC staff arranged for a special TV broadcast on the Earth-Orbit link from Ryumin's apartment. The "show" was hosted by cosmonauts Kovalenok and Sevastyanov and featured a birthday cake with 41 candles baked by his wife (he was unable to blow out the candles *via* the TV!). Actors Yuri Vizbor and Sergei Nikitin sang a specially composed song in which the families and friends present joined.

Popov's 35th birthday was celebrated on 31 August with another Earth-Orbit TV linkup. The events provided the cosmonauts with a break from their strenuous work 340 km above the Earth.

Preparations for Another Start

On 4 September the orbit of the station was corrected raising the period from 91.14 to 91.3 minutes. The height after the burn was 343 × 355 km in the standard 51.6° inclination. A further refinement to the orbit on 16 September left the Salyut 6/Soyuz 37 complex in a 91.4 minute period track in readiness for the next Interkosmos launch. September 16 also saw the activation of a reserve Salyut ODU motor (the first such use for two years following the fuel tank leak diagnosed shortly before the end of the Photons' flight).



Designed to investigate space and motion sickness, the European Space Sled Vestibular Experiment is being watched with some interest in the United States (though unfortunately it has been dropped from Spacelab 1). The Spacelab One science crew members are pictured in a Spacelab simulator at MSFC.

NASA

Dr. Ken Money and Dr. Richard Malcolm are members of a six-scientists team (including Professors Larry Young and Chuck Oman of the Massachusetts Institute of Technology in Cambridge and Professor Geoffrey Melville Jones and Doug Watt of McGill University in Montreal) which submitted experiments for NASA sponsorship. The experimental programme directed by Professor Young involves closely related experiments that seek the answer to basic questions: How does the human sensory motor system reorganize itself when one of the channels through which it receives information is inoperative because of zero gravity, and what changes occur in the balance governing the vestibular system as the body becomes accustomed to space travel.

Space motion sickness has occurred on several American and Soviet missions and affected the productivity and well-being of astronauts. Although the Skylab results indicated that humans can adapt to zero-g environment within a week, the problem remains a serious one for the short-term space traveller. It is especially critical to the future of the Space Shuttle Spacelab experiments because many of the payload specialists for orbital flights will be engineers and scientists who have not undergone extensive training as astronauts.

MARS PHOTO BOOK

All but one of the four Viking spacecraft sent to explore Mars are silent now, but they have left a legacy of hundreds of remarkable photographs of the Red Planet.

Some of the best of these are included in a new NASA paperback publication entitled "Images of Mars: The Viking Extended Mission." Collected by Nancy Evans of the Jet Propulsion Laboratory, and Michael H. Carr of the U.S. Geological Survey, the pictures illustrate the varied landscape of one of the Earth's closest planetary neighbours.

The 30 black and white photographs in "Images," some as recent as 1979, were selected not just for their visual impact, but for what they tell the viewer about the terrain they depict. Soaring volcanos, mysterious channels, tremendous chasms that could swallow the Grand Canyon, rocks, boulders and sand - all are shown in vivid clarity. The notes accompanying each photograph explain, in layman's terms, what each image shows.

The paperback is available for $2.25 plus postage from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Quote publication number NASA SP-444.

FREEMAN DYSON AT JPL

Theoretical physicist Dr. Freeman Dyson, a leader in studies of new spacecraft propulsion systems, has been named a Distinguished Visiting Scientist at the Jet Propulsion Laboratory, JPL Director Bruce C. Murray has announced.

Dyson, a professor in the School of Natural Sciences of the Institute for Advanced Study at Princeton, participated in Project Orion at the General Atomic Laboratory in San Diego from 1958 to 1965, studying the potential use of small nuclear explosions to propel manned spacecraft.

In 1977, Dyson led a study of laser propulsion for the Defense Advanced Research Projects Agency (DARPA), and has since been actively involved in studies of solar sailing and the NASA Search for Extraterrestrial Intelligence (SETI) project.

Born and educated in England, Dyson is the author of the book "Disturbing the Universe."

He joins Professors Jacques Blamont of France, Giuseppe Colombo of Italy, Richard Goody and Gene Shoemaker of the U.S., Michael Longuet-Higgins of the U.K., and Klaus Hasselmann of Germany as a Distinguished Visiting Scientist at JPL.

VOSKHOD - IT'S OFFICIAL

On 18 March 1980, the USSR's Postal Administration celebrated the fifteenth anniversary of the first space walk by issuing a miniature stamp sheet. The 50 kopeck stamp depicts Alexei Leonov floating in space, but the more interesting part

is the surround, writes Robert Christy. It shows Voskhod 2 as seen by Leonov, and in fact the sheet is Leonov's design. It is based on one of his own paintings. The miniature sheet is probably the first official Soviet document to admit the close

relationship between Voskhod and Vostok. The spacecraft is depicted with the inflatable airlock extended from the spherical cabin and the hatch open. Vostok's four long HF aerials are present, along with the porthole and the ring of pressurised gas bottles surrounding the base of the cabin.

The device on top of the sphere does not show any forward pointing rocket nozzles where some observers place the reserve retro-rocket. However, this does not exclude the possibility of it having a jettisonable cover.

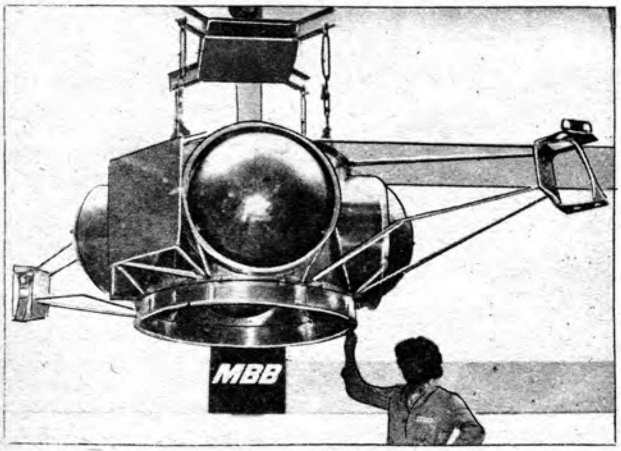
The new sheet contrasts greatly with the one issued just after the flight, in 1965, where a comic strip spaceman floats outside the square door of a domed, cylindrical spacecraft.

ENGINES FOR GALILEO

NASA's Jupiter orbiting probe, Galileo, which is due for launch in the mid-eighties will use a European built engine system, writes Robert D. Christy.

Development and construction of Galileo's propulsion unit has been entrusted to the Messerschmitt-Bolkow-Blohn company in Federal Germany. The 1033 kg module will consist of one main 400 Newton thrust chamber and thirteen smaller, 10 Newton thrusters for attitude control and minor manoeuvres. Of the total mass, 850 kg will be the bi-propellant fuel mixture of monomethyl hydrazine and nitrogen tetroxide (N_2O_4), the technology for which stems from experience with the Franco-German 'Symphonie' satellites.

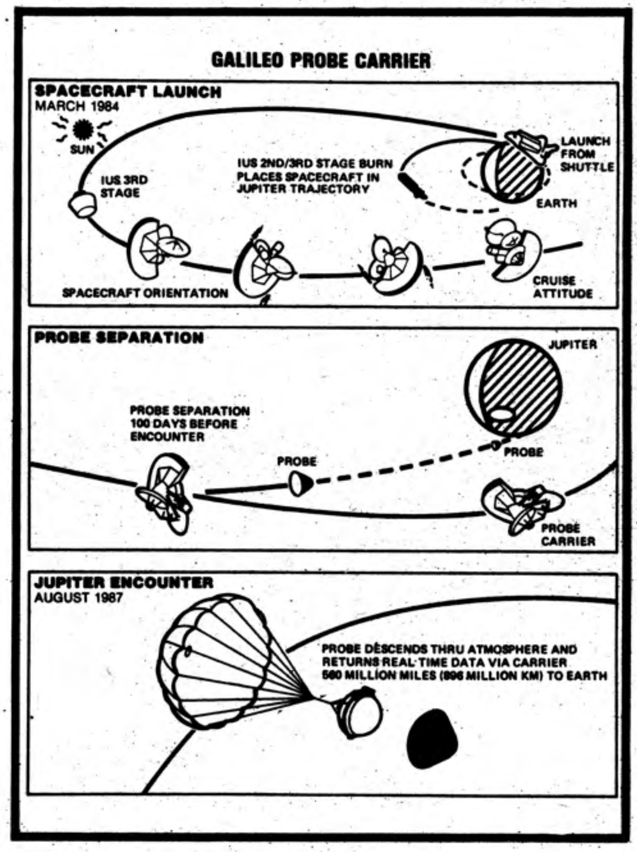
The propulsion unit will not be in operation during the early stages of Galileo's flight which will be a Shuttle launch. The JPL upper stage of the Shuttle system will remain attached until Mars fly-by when the MBB unit will take over.

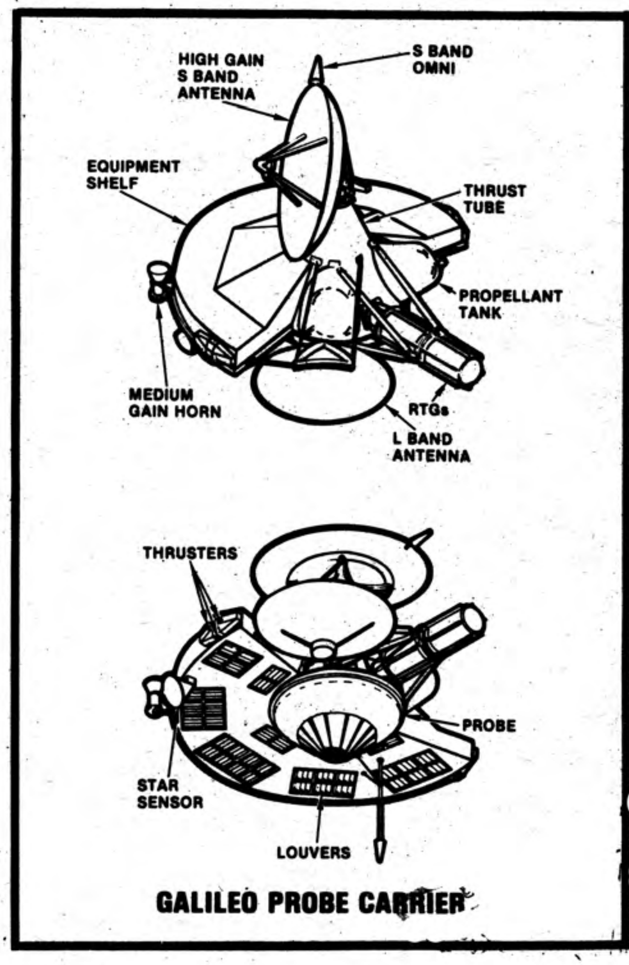


Full size, working, engineering model of the Galileo propulsion module in MBB's integration hall at the Ottobrun factory.

MMB

The module is being built at MBB's Ottobrun factory and at the end of 1979 underwent a successful 75 minute test of the main thrust chamber.





Right, in a separate experiment the Galileo probe carrier will be launched by the Space Shuttle in March 1984 using the Inertial Upper Stage (IUS). The probe will be released for entry into the Jovian atmosphere 100 days before encounter in 1987. Scientific data transmitted by the probe during its descent will be received by the carrier and relayed over 560 million miles (901 million km) to NASA's deep space network.

Hughes Aircraft Company

SIR WILLIAM CONGREVE (1772-1828)

Visitors to the Society's new Headquarters Building in Vauxhall will not have failed to notice the magnificent portrait of Sir William Congreve, the 19th century pioneer of British rocketry. The painting, which has been cleaned and restored, is on loan to the Society. Below we give a brief account of Congreve's life and work.

Introduction

Born in Marylebone, Middlesex, on May 20th, 1772, William Congreve, the future second baronet of Walton, was the son of a distinguished British officer, Lieutenant-General William Congreve, who, in 1780, became Comptroller of the Royal Arsenal at Woolwich. Young Congreve received his elementary education at Hackney School, near London, and at Singlewell School, Kent. As a 13-year old schoolboy he early showed an interest in an area of technology that would occupy a goodly part of his future life. Only two years after the pioneering balloon flight of the Montgolfier brothers in France, young William wrote to his father and enclosed a sketch of a balloon launching. Characteristically self-confident, even at that early age, he wrote that he was ". . . fully beset on going to the Moon in an aerial balloon."

In 1793, he received his AB degree from Trinity College, Cambridge. Two years later, he obtained his AM degree there. Congreve then studied law at the Middle Temple for a while and had a short-lived and disastrous career as a journalist. As editor of a political newspaper, he was sued for a libel against Lord Berkeley. He lost and was forced to pay a fine of £1000, a considerable sum in those days.

However, journalism's dubious loss became rocketry's indubitable gain.

Having been reared at the Royal Arsenal, Congreve had become familiar with both signal rockets and war rockets, particularly the latter, which had been used by the Indians for centuries. Soldiers returning from India brought specimens to the Arsenal. Undoubtedly these crude weapons appealed to the inventive and inquisitive mind of Congreve. He saw in them a new weapon for use against the growing threat from France.

Experiments with commercially available pyrotechnic rockets, made at his own expense, quickly convinced Congreve that they were useless for development as weapons. By 1804, he was experimenting with rockets of an advanced technology. From the earlier Indian rockets, he adapted the metallic motor case, a technological step forward in producing a combustion chamber that permitted greater pressures for a highly compressed and improved gunpowder charge and, hence, better performance than the cardboard chambers of current "sky rockets". He was forced, by a lack of knowledge of rocket ballistics, to maintain the cumbersome stabilizer stick attached to the side of the motor case.

Sir William Congreve at the age of about 35. The artist was most likely James Lonsdale (1777-1839) and the picture probably the one exhibited by him at the Royal Academy in 1812 with the title of *"Colonel Congreve, Equerry to H.R.H. the Prince Regent"*.

The painting, in oils on twill canvas, has been re-lined, cleaned and restored. It is in its original frame which has also been restored.

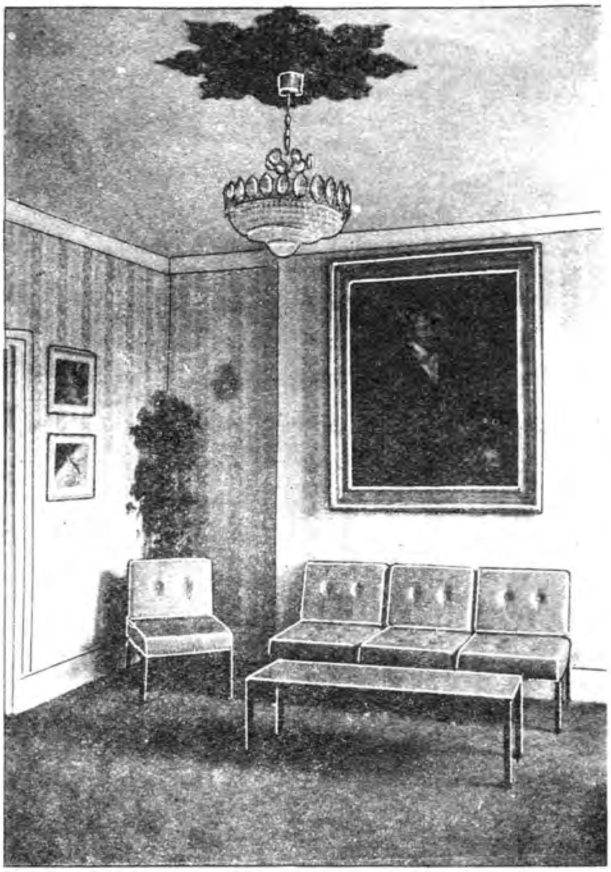
The picture is similar to an oil painting by James Lonsdale exhibited at the Royal Academy in 1808, though this was a full length portrait of Sir William, subsequently engraved in mezzotint by G. Clint in 1809. This painting showed Sir William directing the firing of rockets at the siege of Copenhagen in 1807. At that time the British Forces were commanded by Right Hon. Lord Cathcart. As far as we know, the picture is now lost. The only reference we have is to a reproduction of it from the Witt Library, part of the Courtauld Library.

The Challenge of Napoleon

With the threat of an invasion of England by Napoleon becoming really serious, Congreve convinced the Government that the rocket was a weapon that might well counter the threat. By 1805, he had developed a rocket with a range of some 2000 metres. It was demonstrated, at the urging of his friend the Prince Regent (to whom he became chief equerry in 1817), to William Pitt, Lord Castlereigh and Lord Mulgrave on the ranges at Woolwich. Taking advantage of the occasion, and utilizing his talents as a salesman, he made the point to those present that the range of the rocket could easily be extended to 3000 metres, carrying a 7-pound incendiary warhead, equal in destructive power to that of the current 10-inch mortar. His rocket could be fired from a very light-weight tube or tripod, easily carried by one man. Furthermore, this launcher produced no recoil and was ideal for use aboard small barges and boats. Then Congreve made a most impressive point: the 10-inch mortar projectile cost £1/2s/7d, apart from the cost of its expensive launcher. His rocket was cost-competitive at £1/1s/11d, but its launcher was far cheaper. Pitt must have been especially impressed, after a decade of expensive war paid for by the Nation's first income tax.

As a result of Congreve's demonstration and salesmanship, the facilities of the Royal Arsenal were put at his disposal for the development of war rockets for use by land and sea forces.

Their use is well known and documented at Boulogne, in two attacks against Copenhagen, which was half-destroyed by fire in 1806, largely through Congreve rockets; and later, at Leipzig, with less spectacular results. The Americans immortalized the Congreve rocket, if not in name, at least in its employment against Baltimore in 1814. "The rocket's red glare" became a phrase in the national anthem. Other nations in Europe, as well as North and South America, adopted the Congreve rocket during the first quarter of the 19th Century. Congreve was awarded the Order of St. Anne, second class, by the Czar, and the Sword of Sweden, by the Swedish Monarch, for his weapon and its use during the Napoleonic wars.



General view of Society's reception area showing the Congreve painting in its setting.

First Rocket Manual

Congreve published his first manual on his rocket and its ancillary equipment in 1807. It is interesting to note its title: "A Concise Account of the Origin and Progress of the Rocket System". Much to his credit and to the advancement of rocket technology, Congreve innovated the concept of fielding a new weapon by considering it as a *system*. He gave as much attention to the launcher and to means of transportation as to the rocket. A year before his death, with two decades of experience behind him, Congreve, in 1827, published an expanded version as "A Treatise on the General Principles, Powers and Facility of Application of the Congreve Rocket System, as Compared with Artillery". Again, he stressed the *systems engineering* features of his weapon. In these publications, he stressed his conviction that the rocket ". . . ammunition without ordnance; it is the soul of artillery without the body."

He was, on occasion, frustrated at the Royal Arsenal. His enthusiasm and dedication to rocketry worked to his disadvantage. In 1810, Congreve had attempted to improve reliability and quality assurance in rockets by the use of steam-driven presses for loading propellant charges. However, the advance in the state-of-the-art was refused because of the costs involved. It was not until the 1850's (after Congreve's rockets had been supplanted by those of William Hale) that such a manufacturing innovation was made at Woolwich.

Four years later, he succeeded his father both to the baronetcy and to the older Congreve's position as Comptroller. One of the new Sir William's problems was that he was not an officer in the Royal Artillery. His only military rank was in the Hanoverian Artillery, which little impressed his peers and even his subordinates at Woolwich.

Congreve also established a rocket factory of his own in Bow, which manufactured weapons for sale to the East India Company and other foreign nations.

In addition to his war rockets, Congreve also produced an illumination rocket, the payload of which descended by parachute.

He also tried, without much success, to adapt his rockets for carrying lifelines to stranded or sinking ships and for harpooning whales.

Other Interests

Despite the association of his name with rocketry in the 19th Century, Congreve was a man with many interests. In 1812, he was elected to Parliament from Catton and was later returned twice from Plymouth.

In 1823, he was commissioned by the Government to make a study of the gas lighting systems currently in London. In doing so, he pointed out several potential hazards (and calculated that a gasometer of 30,000 cubic feet was equal in explosive potential to 62 barrels of gunpowder).

The holder of some 18 patents, his inventions included an improved recoil mechanism for cannon, a hydropneumatic canal lock and gate, a time fuse for artillery projectiles, a special paper and process for the prevention of bank-note forgery, an inclined plane, a gas meter, and, not much to his credit, a perpetual motion machine.

As his life drew to an end, Congreve was caught up in the mania for speculation that ruined so many men of his class during the mid-1820's. He became involved in a South American mining scheme; and when the bubble inevitably burst, he was found guilty of fraud. What followed is delicately put by his obituary in the *Annual Register*, 1828. ". . . it is melancholy to have to class him with those individuals of previous respectability the influence of whose example decoyed so many weaker minds to ruin, during that mania for speculation which, two years ago, desolated with such cruelty the commercial community. On the ebbing of the tide, Sir William found it necessary to take refuge on the Continent."

Sir William Congreve, 2nd baronet of Walton, died, partially paralyzed, on May 16th, 1828, in Toulouse, just four days shy of his 56th birthday. One wonders if his death took place in his final invention: a wheel-chair that converted into a bed. He was buried in the Protestant Cemetery.

Conclusion

While not an engineer in the modern sense of the word, Congreve was a well-educated and talented man who made a significant contribution to the advancement of the state of the art of rocketry in the 19th Century. Indeed, he developed the gunpowder rocket to its ultimate state within the resources and knowledge available to him. Yet, like so many pioneers in every field of science and technology, he died after having failed to solve a problem with which he had long been involved: directional stability in the rocket, or in modern parlance, guidance and control. This failure notwithstanding, his fame as a pioneer in the field of rocketry is well deserved and secure.

HIGH LIGHTS

Indonesia will add 20 rural Earth terminals to its satellite communications system to meet the demand for more links between its various population centres. Hughes will supply components and technical services for the new terminals, which are to be on-line in late 1981. Already, more than 115 Earth terminals are operated by Perumtel, Indonesia's national telecommunications company. Hughes, which built the two Palapa satellites now serving Indonesia, is manufacturing two more powerful Palapa-B satelittes for launch in 1983.

CHESLEY BONESTELL EXHIBIT OPENS

by James Sweeney and Thecla Fabian

It comes as a shock to realize that "New York and Long Island from 25 Miles Up" is not a Landsat photograph. It is even more of a shock to realize that Chesley Bonestell painted this view of Earth in 1949, eight years before the launch of Sputnik. Seeing a group of Bonestell's paintings together impresses the viewer even more with the accuracy and concern for detail in his work.

The Smithsonian National Air and Space Museum in Washington, D.C. is currently featuring an exhibition of paintings by noted space artist Chesley Bonestell. Eighteen of his paintings of spacecraft, possible future man-made space structures, the planets and other heavenly bodies will be on display through 1981. The show is a prelude to a major permanent exhibit of Bonestell's work which will open at the museum in 1982.

Bonestell's graphic realism and haunting beauty have earned him a reputation as the foremost space artist of our time. His varied career has included not only illustrations for books and magazine articles, but murals for buildings, matte work for films, architectural rendering, interior design and a series of paintings of the Spanish missions in California.

Born in California in 1888, Bonestell showed an early talent for drawing. His interest in space art developed at the age of seventeen while he was working as an artist for *Sunset Magazine*, which was then owned by the Southern Pacific Railroad. His pay was in the form of railroad passes, one of which he used to visit the Lick Observatory. There he first saw the Moon and Saturn through the large telescopes. From that time on, much of Bonestell's work focused on the planets, especially Saturn and the Moon. The works in the Smithsonian exhibit are later examples of his treatment of these topics. The paintings resulting from his early visits to Lick Observatory were destroyed in the 1906 San Francisco earthquake and fire.

At his family's urging that he take up a "proper" career, Bonestell pursued architectural studies at Columbian University in New York. From there, he moved to London, where he again worked as an artist on the *Illustrated London News* and various London papers. Returning to the United States in 1927, he worked as an architectural renderer on such projects as the Golden Gate Bridge and the Golden Gate Exposition in San Francisco, the Supreme Court Building in Washington D.C., the Chrysler Building and several other large skyscrapers in New York. Bonestell credits his technical training and draughtsman's work for helping him develop his realistic, accurately rendered style. This architectural training manifests itself in the meticulous structural detail seen in his speculative paintings of future space assemblies.

In 1938 he went to work as a matte illustrator in Hollywood, working on scenes and special effects in such films as *The Hunchback of Notre Dame, War of the Worlds, Destination Moon, When Worlds Collide, Citizen Kane, The Horn Blows at Midnight, Mr. Deeds Goes to Washington, How Green Was My Valley, The Swiss Family Robinson, Mark Twain*, and *The Magnificent Ambersons*. Bonestell was in demand as a matte painter, especially for science fiction films. *Destination Moon* is considered a classic of scientific accuracy in script and special effects. NASA lists the film in its chronology of events which inspired and led up to the first manned landing on the Moon in 1969.

After World War II, Bonestell began a long collaboration with rocket pioneer Wernher von Braun and space writer Willy Ley. He illustrated many books about space and space travel, including *The Conquest of Space, Conquest of the Moon, The World We Live In, The Exploration of Mars, Beyond the Solar System, Mars* (with Dr. Robert S. Richardson), and *Beyond Jupiter* (with Arthur C. Clarke). His work also appeared in a number of magazines, including *Colliers, Look*, and *Life*. The von Braun/Bonestell articles for *Colliers*, which ran in the early 1950's, covered the mechanics of space travel, building spacecraft in Earth orbit, and trips to the Moon and Mars. The series was very popular, and made many people aware that space travel would soon be technically feasible. Equally as important, not only for increasing public awareness of space, but also as a classic of space art, was his collaboration with Willy Ley on *The Conquest of Space*, published in 1949.

Not New York and Long Island from 25 miles up, but the planet Mercury - painted by Bonestell in 1949.

Copyright Chesley Bonestell
Smithsonian Institution,
National Air & Space Museum

Bonestell's collaborators have expressed both praise and frustration for his determined search for scientific accuracy. In 1964, von Braun said of his work:

Chesley Bonestell's pictures . . . are far more than . . . beautiful, ethereal paintings of Worlds Beyond. They present the most accurate portrayal of those faraway heavenly bodies that modern science can offer. I do not say this lightly. In my many years of association with Chesley, I have learned to respect, nay fear, this wonderful artist's obsession with perfection. My file cabinet is filled with sketches of rocket ships I had prepared to help him in his art work — only to have them returned to me with penetrating detailed questions or blistering criticism of some inconsistency or oversight.

In 1976, the British Interplanetary Society honoured Chesley Bonestell with an award recognizing a lifetime of achievement as an artist and renderer of speculative science.

Today, at the age of 92, Chesley Bonestell continues to paint daily at his Carmel, California home.

The eighteen paintings at the temporary Smithsonian exhibit offer a fascinating overview of the work of a man who is one of the masters of the art of the space age. The works exhibited show the development of his style over the last thirty years and his awareness of advances in the space sciences. The future permanent exhibit promises to be an exciting and important addition to Washington's National Air and Space Museum.

BOOK REVIEWS

Handbook of Soviet Lunar and Planetary Exploration
By Nicholas L. Johnson. (AAS Science and Technology Series, Volume 47.) Univelt Inc, 1979. 282 pages.
Handbook of Soviet Manned Space Flight
By Nicholas L. Johnson. (AAS Science and Technology Series, Volume 48.) Univelt Inc, 1980. 461 pages.

Although the Soviet space programme dominates space, authoritative works on the subject are hard to come by. In addition, when one obtains a book on the subject it is often difficult to tell what is official Soviet data, what are the author's reasonable deductions from Soviet data and what are the author's speculations. The two volumes prepared by Mr. Johnson bring together most of the available data in the field of Soviet lunar, planetary and manned space flight, generally based upon a careful reading of official Soviet data, with the writer's extrapolations being clearly stated as such.

The work was originally conceived as one volume, but it grew to such a size that it had to be split into two more manageable volumes. The first of the two volumes reviews the history of the Luna, Mars and Venera programmes, together with the Zond series (one Section deals with the Zond lunar flights, with the Zond 1 and Zond 2 missions being considered in the Venus probe and Mars probe Sections respectively). The inclusion of the Zond 4-8 missions in the volume covering *unmanned* space exploration may surprise some, but after all these craft did not carry men, although they were capable of doing so. The possible Soviet manned lunar programme is reviewed in this volume.

The real "meat" of Mr. Johnson's work lies in the second volume, dealing with the Vostok, Voskhod, Soyuz and Salyut programmes. One feels that it would be difficult to obtain a more detailed review of the various spacecraft from western sources. The Soviet manned programme has been the subject of much speculation in the past, and it is a refreshing change to find a review which keeps speculation to a minimum.

Of course, it is impossible to be totally up-to-date with books covering the Soviet space programme, but in this respect Mr. Johnson has excelled himself. Although the bulk of the books is correct to the end of 1979, one finds the 1980 missions to Salyut 6 up to and including Soyuz T-2 covered in some respects.

The two books are fully illustrated with both black-and-white photographs and line drawings. In respect to the latter, the principal artists Richard Escarcega and Ralph F. Gibbons are to be complimented for their outstanding work.

Full and detailed references are given for each Chapter in the two volumes: the books share common appendices dealing with launch sites and launch vehicles and a common bibliography is supplied.

All in all, it would be difficult to find two better books covering these aspects of the Soviet space programme.

PHILLIP S. CLARK

WHY?

Some reflections on the philosophical aspects of space exploration.
By Michael W. Taylor

Introduction

A child's thirst for knowledge, its capacity for asking 'why?', is almost proverbial. Often we realise that the child produces questions which are ungrammatical and logically unanswerable; however being unable to explain this to our youthful inquisitor we may only answer lamely "It's just the way things are." This article attempts to show that it is not only children who are guilty of such errors.

If the history of ideas relating to the exploration of space is ever written there will surely be a chapter devoted entirely to the attempts to see this, the greatest of all human endeavours, as part of a wider philosophical scheme. The most notable examples of this form of speculation are probably Dr. Olaf Stapledon's "Interplanetary Man?" and his novels, together with the science fiction of Arthur C. Clarke. (I would like to make it clear that these authors are in no way being singled out for attack; I wish in no way to belittle their magnificent achievements).

The belief which they have tried to convey in mankind's cosmic destiny, of the evolutionary importance of space exploration, may I think be seen to answer the age old questions "What is the meaning of life? Why was the Universe created? Does it have a purpose? And if so, what is man's place in that purpose?" The questions are given a particular, sophisticated form, but they are nevertheless there, at the root of these speculations.

However it is my contention that the questions themselves, for so long considered the most profound which it is possible to ask, questions which have engaged some of our finest minds over the centuries, are literally nonsensical.

Why the Universe?

Consider for example what has happened to 'why?' when it is transplanted into the sentence "Why does the Universe exist?" To be sure, it is composed of the same three letters as before; but analysis will show that it has lost all its old meanings without gaining any new ones. When we ask "Why?" of any event, which we shall call x, then we expect that there is some other event or set of circumstances which brought about event x but which are distinct from it. This is indeed the basis of cause and effect: projectile A strikes a second body B, imparting to it some of A's velocity. The motion of B is event x, the collision of A with B is the event which has caused x, but it is a totally separate event. To give a less abstract example: the crash of an aeroplane may be due to metal fatigue; again the event is brought about by something external to the event itself.

A moment's reflection will show, however, that when we ask 'Why?' of the Universe, if by "the Universe" we mean everything which exists, then *logically* there can be nothing external to our event to cause it. This point was put succinctly

by Ludwig Wittgenstein when he wrote "The sense of the world must lie outside the world" [1]. But logically there can be nothing outside the world.

This argument may be objected to on the grounds that "the Universe" of which we are aware may not be all that exists. I can imagine my critic suggesting the existence of "parallel universes" and the like. The objection can I think be answered by means of a digression on the foundations of meaningful discourse.

What do we mean by a "factual statement"? Clearly it must be one which is capable of being either true or false; thus the first test which a statement must pass to be considered factual is that it must fit the formula "Is it true that x?" where x is the statement. For example the sentence "There is a planet 93 million miles from the sun" is factual because it is clearly possible to ask "Is it true that there is a planet . . ." etc. This first test serves to exclude other forms of meaningful discourse, for example, commands, questions, poetry.

Secondly, having established that a statement is factual in this sense it must then fall into one of two groups. The first of these groups is what the Scottish philosopher David Hume called "Relations of Ideas", that is, the propositions of maths and logic. These we may treat as being true by convention, and therefore in a technical sense they are "tautologies". The proof of this is too long and complicated to reproduce here, but in very simple terms two plus two *must* equal four since they are by definition identical. Hence "two plus two equals four" contains nothing more substantial than the truth that "a yard" equals "three feet".

The second group of factual propositions are those which express "matters of fact": in order to possess any factual meaning they must be capable of verification by reference ultimately to sense experience. Statements about tables and chairs, for example, are merely statements about hypotheses which are the best explanation of sensory experience. Furthermore, although it is not possible for us to observe individual electrons, these too are similar hypotheses which explain our sensory experiences. Therefore statements about "matters of fact" are nonsense unless it is possible to verify them by reference to empirical data.

Now beyond these two groups of statements we can say nothing about the world which will pass the first test. Thus it follows that if, as I argue, the sense of the Universe lies outside it, then all talk of this "meaning" lacks factual basis since we can speak factually only about that which is empirically verifiable, i.e. within "the Universe" of which we are aware. Thus I believe that our critic has been successfully answered.

Sophistry and Illusion

Having adopted these rules of factual meaning we find that much of the so-called "philosophy" of the past, and indeed all attempts to answer the "why" of the Universe, are shown to be without factual basis; in the words of Hume they are "sophistry and illusion". Since this is the case, the questions themselves would appear to be pseudo-questions, for to quote Wittgenstein:

"If a question can be put then it *can* also be answered . . . doubt can only exist where there is a question, a question only where there is an answer, and this only where something *can* be *said*" [2].

We have seen that trying to answer the "why?" of the Universe necessarily entails trying to say what cannot be said in terms which have any factual basis. Hence there can be no question, since nothing can be said by way of an answer.

The quotation from Wittgenstein highlights a second strand of my argument. Note that he says that a question may exist "only when there is an answer". Indeed if we analyse the meaning of a question then ultimately our analysis is nothing but a description of the way in which the question itself may be answered:

"Every explanation or indication of the meaning of a question consists, in some way or other, of prescriptions for finding the answer . . . It may be empirically impossible to follow these prescriptions, but it cannot be logically impossible" [3].

A good example of this kind of question, which is empirically but not logically unanswerable, would be: "What did Newton have for breakfast on his twentieth birthday?" Unless he kept a daily record of his eating habits which is still existent, it is unlikely that we shall ever know whether, for example, he had bacon and eggs. But it is not *logically* impossible to answer this question because we know what kind of an answer would satisfy our request for knowledge. However, there may be a third group of questions which are unanswerable *in principle.* When we consider particular questions:

"We can either give them a definite meaning by careful and accurate explanations and definitions, and we are sure they are solvable in principle . . . or we fail to give them any meaning in which case they are unanswerable" [4].

When we analyse carefully a question like "What is the meaning of life?" then it becomes clear that we cannot give it any definite meaning. If the word "life" appeared within inverted commas in the sentence, then sure enough we could answer the question by resorting to the use of a dictionary. But in the form in which it appears it is too vague, too elusive to be capable of the precise definition and explanation which would make it answerable, if only in principle. One might just as well ask what the Universe had for breakfast as ask for the meaning of life.

Justification for Space Exploration

The consequences of our investigations are, I think, twofold. *First* we should not seek any "philosophical" or pseudo-philosophical justification for space exploration because there is none to be found. *Secondly* the sole justification must therefore be the benefits which will accrue to mankind from the exploration of space. This conclusion has a direct bearing on the recent "economic" arguments in the correspondence pages of "Spaceflight". I do not, however, intend to consider those here.

I may be accused of being like the greyhound which, itself refusing to run, bites all the other greyhounds to stop them running too. In my defence I would say that I am justified in that I have realised the hare after which we have been chasing is not a real one.

Space exploration is not however lacking in philosophical significance, or rather, significance for the philosopher, particularly if contact is made with another intelligent race. If such a meeting ever did take place then it could add a good deal of grist to the philosopher's mill. He would for example have the opportunity of examining the way in which a completely alien language produced a representation of reality. It could too help resolve a long-standing dispute over the status of mathematics and logic; are they for example inherent in the Universe or are they merely the product of the human mind imposed on reality like a grid on a map. Similarly our ideas of beauty and of right and wrong. And finally, perhaps the most exciting idea of all, a whole wealth of philosophy may await us a mere 100 light years away!

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2. *Ibid*, 6.5 and 6.51, Wittgenstein's italics.
3. Moritz Schlick, "Unanswerable Questions" (written by Schlick in English. Published in *The Philosopher* (1935)).
4. *Ibid*.

SOCIETY NEWS

CLARK REVIEWS SPACE FLIGHT

On 8 October 1980 a talk was given to Society members by Phillip S. Clark, the subject being a review of space flight activities over the previous eighteen months or so. The meeting was in three parts: a slide show, a short talk about topics not covered by the slides, and finally questions and answers.

The topics covered by the slide show were:

- European Meteosat photographs;
- Events leading up to the first flight of the Ariane launch vehicle;
- Pioneer 11 encounter with Saturn;
- Voyager 1 and Voyager 2 encounters with Jupiter;
- The current status of the American space shuttle system, and
- A brief review of Salyut 6.

Following the slide show, a verbal review was given of various unmanned space activity undertaken by the various "space nations", together with a more detailed review of the 1980 activity on board the Soviet Salyut 6 orbital station. At the time of the meeting the cosmonauts Popov and Ryumin were still in orbit, although the Soviet Union had announced their impending return and the possibility of further manned visits to Salyut.

The final half hour of the meeting was given over to questions and answers: although the topics covered by the speaker had included world-wide space activities, most interest was expressed in the Soviet space programme with only one question being asked about the American programme. Most interest was expressed in the future direction of the Soviet programme, and the prospects for a Soviet space shuttle. Other questions covered the medical condition of cosmonauts after long missions and the reports in the summer of 1980 that the Soviets were re-developing their giant launch vehicle for use in the launch of a 12-manned orbital station in the mid-1980s.

It is planned to make this type of meeting a regular event in October each year (the anniversary of the first satellite).

The Gentle Art of "Growing Up"

An Open Letter to all Society Members

In 1933 a small group of enthusiasts found that they had ideas in common with, as their main theme, the exploration of space and the possibility of going to the Moon. They had, as a basis for these strange notions, sets of maths equations which showed that rockets would work in vacuum just as well or even better than in the Earth's atmosphere.

The numbers of enthusiasts swelled when details were published, complete with engineering drawings and sketches, of a rocket propelled vehicle which could land Men on the Moon and return them to Earth. All of this had been conceived when the fastest aircraft available were special machines capable of approaching 450 mph and which had been specially designed to break World Airspeed Records. The enthusiasts were talking of reaching speeds of **25,000 mph** in order to reach the Moon. No wonder they were labelled "cranks", or that most damning of polite British euphemisms, "enthusiastic amateurs".

The amateurs pressed on and in time found themselves a name, "The British Interplanetary Society". It completely described their nationality and adequately outlined their aims.

Then the 1939-45 War intervened and, in modern parlance, the members of the Society reduced their activities and "kept a low profile". When hostilities ceased the Society was re-formed and the flame of enthusiasm flared to its former brightness. Though developed as an engine of War, the Society was determined to see that the rocket was also allowed to reach its full potential as a means of opening up the Space Frontier and taking Man to the Moon and the Planets. One member forecast the use of rockets and satellites for radio and TV broadcasts.

Now, nearly 50 years have passed. We celebrate our Golden Anniversary in 1983. The little group of enthusiasts has grown to nearly 4000 members from all walks of life. Professional and non-professional alike rub shoulders, talk about their interests and listen to lectures and read the two regular publications produced by the Society.

But the natural enthusiasm which ruled, governed and controlled the little band of pioneers is not enough for a thriving group of 4000, very many of whom are not in the UK but overseas, in the 'States and elsewhere.

In short, the Society is growing up and, just as for most children, growing up has seemed an initially slow process followed by a fast gallop. The immature larva of 50 years ago is now going through the final chrysalis stages very quickly before flexing its wings, sunning itself and setting out on the next stage — that of full maturity. But this is not the maturity of an insect destined to last a few days and die. The Society is determined to **live** and the proof of its new determination to survive and expand is exemplified in its new Headquarters. The little band of pioneer enthusiasts are now responsible property owners. The Society they nurtured must be accountable for rates as well as rockets. The chrysalis *must* break open to produce the splendid final product, but we should remember that there are other ways of fracturing the structure which binds us together. These other ways could mean the total disintegration and death of the Society we all know and strive to support.

Enthusiasm alone is not enough to control and develop a Society of nearly 4000 people. Rules, regulations, bye-laws and other statutory devices must be brought into play to allow the Society to live, organise itself efficiently and grow even larger as it undoubtedly can.

A little clique of people feel that the Society is becoming "hidebound" or "stuffy" or "over-professional": "dictatorial" has also been muttered, all words calculated to give the impression that attempts are being made to strangle enthusiasm.

Not so. If the protesters stopped shouting and reflected quietly they would realise that they are asking the clock to be turned back 50 years. "Let us have our little Club again". "Let us talk about X and Y (here the reader can choose his own pet subject) and chat to our friends".

We cannot turn back the clock even if we wished to do so. We cannot go back to the 1930's atmosphere for if we did it would kill the Society quicker than David's stone killed Goliath!

Our Society is now becoming rapidly accepted as a Learned Society, yet the spirit which founded the Moon Rocket of the 1930's glows just as bright if not brighter! A recent publication "Project Daedalus" shows detailed engineering drawings of a ship to take the artifacts of Man to the stars at 10% of the speed of light. In other words, Man will go by proxy and send an intelligent starship in his name, to spy out the stars, planets and characteristics of other solar systems. The original BIS Ship appeared in 1937-38 and Apollo landed on the Moon in 1969 just 31 years later. The grown-up BIS published Daedalus in 1977. *If* the idea were followed by an exactly parallel development programme, the prototype starship would be with us in 2008. Even the most enthusiastic of us would agree that this seems optimistic. But meanwhile we have a whole Solar System to explore and the prototype Daedalus could do just that. Nine planets, some 40 satellites and hundreds of asteroids await our exploration, analysis and utilisation. This will take time, and during that time the original starships developed and despatched will begin to report back on what they have seen and sampled. And we then face a major step. Where the machines went, is it possible for Man to follow? At present we do not know but knowledge will steadily accumulate to answer the question one way or another and hopefully that answer will be YES. The BIS will play a key role

in generating and acquiring such expertise and knowhow.

Knowledge is accumulated in the papers, books (and eventually) computer records of learned societies. *Beyond the initiating point very little more can be done by enthusiasts who just talk*. The hard graft of researching, acquiring and publishing knowledge and responsibly accumulating it is done by professionally-organised groups, to which our BIS now properly belongs.

We cannot move *back* to the enthusiastic amateurs with limited means; we must move *forward* as a respected and learned group that stands on its own feet, organises itself in a professional manner, and whose voice is respected when heard. Your Council is dedicated to just those aims, and is cautiously but responsibly exploring ways and means by which its professional standing may be furthered and enhanced.

We cannot yet be sure if Man will go to the Stars as he went to the Moon but we can labour to that end. The Society's founders saw *their* dreams come true — they were (and are) fully justified prophets. We of today can discuss, plan, design and publish data and knowledge that ever so slowly but ever so surely can set Man on that course.

But if we surrender to nostalgic talk of the 'pioneer' days, then our Society, all it represents and all its present achievements, will be buried and forgotten as if it had never existed — and *this* could be our destiny in 2008!

Now we are rapidly coming of age, and when *all members* be they student or President are talking to others who are outsiders they wear the "cloak and badge" of the Society as surely as if they wear a BIS T-shirt. To those outsiders, they *are* the Society and are judged as such by what they say and do.

As St. Paul once wrote, "When I was a child, I spoke as a child, I understood as a child, I thought as a child: but when I became a man I put away childish things".

The BIS — through its Council and Officers — has put away childish things! We are passing rapidly through adolescence to a fuller maturity. Reject, completely, all who want a second childhood.

A. T. LAWTON,
Vice-President.

MILESTONES/Continued from page 65

10 Re-entry module of Soyuz T-3 soft lands some 130 km east of Dzhezkazgan at 1226 Moscow time.

16 NASA Ames Research Center selects Hughes Aircraft's space and communications group for negotiation of a $40 million contract to develop the Jupiter-mission Galileo probe carrier. The probe carrier will be launched from the Space Shuttle in March 1984 using an Inertial Upper Stage (IUS).

December 1980

29 Space Shuttle "Columbia" is rolled out from Vehicle Assembly Building to Launch Complex 39A at the Kennedy Space Center.

31 NASA re-schedules launch of "Columbia" for 17 March. Orbital mission to last nearly 55 hours returning to Dryden Flight Research Center, Edwards, California or White Sands Missile Range, New Mexico.

January 1981

6 NASA announces that "Columbia" is undergoing checks on the launch pad according to schedule. Checks of the water flow at the mobile launch platform level have begun. "The water system will be used both to prevent flame and heat damage to the launch structure and also to provide sound deadening to protect the Space Shuttle from intense launch noise vibrations." Prime crew astronauts John Young and Robert Crippen and backup crew Joe Engle and Richard Truly are practising emergency escape from the pad.

NEW AMERICAN SPACE MUSEUM

On 17 February 1980 a signal from the Voyager 1 spacecraft, then 375 million miles from Earth on its way to Jupiter, was relayed to Hutchinson, Kansas, via the Jet Propulsion Laboratory in Pasadena, California. The signal triggered a laser, which detonated and fired an explosive device buried in the ground. This was the unusual groundbreaking ceremony for the Kansas Cosmosphere and Discovery Center, which opened to the public in October 1980.

The Discovery Center contains $85 million worth of artifacts from the National Aeronautics and Space Administration. Included in the more than 1,400 exhibits are nearly 150 items that have been to the Moon and back.

The highlight of the Hall of Space, which opens this spring, will be an entire set of actual working spacecraft, making the Cosmosphere the only institution, other than NASA and the Smithsonian National Air and Space Museum, with a complete collection of American manned space vehicles. The Hall of Space will also have the Apollo-Soyuz trainer that was used in the first manned international spaceflight in 1975. Completely restored back-up Mercury and Gemini craft will be on display, along with a full scale Lunar Module (one of five in existence) and Lunar Module cockpit trainer. The Discovery Center staff has also restored an Apollo Command Module and installed video monitors in the windows and a computer system; visitors will be able to enter the module and experience a simulated trip to the Moon.

The Hall of Space will also have the only Space Shuttle cockpit trainer on display in the United States, with visual projections simulating a Shuttle landing. The Center has one of the largest collections of spacesuits in existence. The 25 suits include early Air Force suits, Mercury, Gemini, and Apollo suits, Skylab flight suits and sleep gear, as well as a set of one-of-a-kind prototype hardsuits.

Inside and outside the building will be a number of rocket engines, including several small thruster engines, a V-2 rocket engine, a Mercury Redstone and Gemini Titan, an H-1, and an F-1 engine from the Saturn V rocket. The hall will feature an exhibit on space benefits and spinoffs.

The other two exhibit halls in the Discovery Center will cover Earth sciences and the atmosphere. The Atmospheric Hall shows the development of air travel. A major portion of the hall will be devoted to the evolution of aircraft cockpits.

The William D.P. Carey Cosmosphere, named for one of Hutchinson's most prominent citizens, will seat 110 people and will feature a Spitz projection system. The Cosmosphere is designed with a tilted dome, so both the dome and the floor are angled at approximately 21 degrees, suspending the audience in the simulated environment.

It will be one of five theatres in the world using the Omnimax film projection system and Imax film, which has frames 51 mm high by 71 mm wide. The first film to be shown will be "To Fly," the award-winning film on the history of flight which premiered several years ago at the National Air and Space Museum. Unlike the Air and Space Museum theatre, which projects the film onto a big flat screen, the Cosmosphere system will project the film onto the dome, filling 86% of its surface.

The original Hutchinson Planetarium will be converted into a solar observatory with a solar heliostat. Visitors will be able to view sunspots and flares as they happen and participate in solar experiments.

The Kansas Cosmosphere and Discovery Center is located at 1100 North Plum Street, Hutchinson, Kansas, USA 67501, on the campus of the Hutchinson Community College.

THECLA FABIAN & JAMES SWEENEY

ASTRONOMICAL NOTEBOOK

by J.S. Griffith*

SOLAR SYSTEM

Composition of Meteorites

A new link between astrophysics and experimental cosmochemistry has been forged with the discovery that primitive meteorites contain small amounts of pre-solar material. The Murchison carbonaceous chondrite contains three isotopically anomalous noble gas components of apparently presolar origin. Similar anomalies are found in the carbonaceous chondrite Orgueil.

These anomalies cannot be ascribed to any processes active within the solar system today, and the presolar origin of the abundances is discussed in ref. [1] with details of the Murchison chondrite in ref. [2] and the Orgueil chondrite in ref. [3].

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3. Eberhardt, P., Jungck, M.M.A., Meier, F.O. and Niederer, F., 'Presolar grains in Orgueil: evidence from Neon-E', *Astrophys* (Letter), **234**, L169-L171, 1979.

An Asteroid with a satellite

Analysis of occultation data of the asteroid (18) Melpomene revealed the existence of a satellite at least 48 km across.

The existence of minor planet satellites has been discussed in earlier papers (ref. [1], [2] and [3]). The secondary occultation of SAO 114159 was photoelectrically observed with the 91-cm reflector at the Fernbank Science Center Observatory (Atlanta, Georgia) on 11 December 1978. Details of the equipment used and the observations are given in ref. [4]. The observations can be explained in terms of a satellite (1978 (18) 1) with a minimum diameter of around 48 km at a distance of around 700 km from the minor planet. It is noted that near opposition (18) Melpomene and its satellite should be visually resolvable or at least reveal an elongated image with a large telescope.

REFERENCE

1. Binzel, R.P. and van Flanders, T.C., 'Minor planets: the discovery of minor satellites', *Science* **203**, 903 (1979).

2. Reitsema, H.J., 'Reliability of minor satellite observations', *Science*, **203**, 205, 1979.

3. Tedesco, E.F., 'Binary asteroids: evidence for their existence from lightcurves', *Science*, **203**, 905 (1979).

4. Williamon, R.M., 'Observation of a secondary extinction during the occoltation of SAO 114159 by (18) Melpomene , *Astronom* **85**, 174-176 (1980).

Atmosphere of Triton

One of Neptune's satellites, Triton, which has long been known to be of appropriate size and temperature to retain an atmosphere, is now found to have an atmosphere that appears to consist of methane gas above methane ice.

Using the Kitt Peak National Observatory's 4 m Mayall Telescope, the authors of ref [1] observed Triton spectrophotometrically in the infrared. There is evidence of absorption due to a tenuous atmosphere of CH_4 with a surface partial pressure consistent with the vapour pressure of gaseous methane in equilibrium with solid methane. The general picture of Triton is of a surface, largely covered with rocky material with a few patches of frozen methane. The dusk side of Triton may act as a cold trap, and there should be observable a methane meteorology.

REFERENCES

1. Cruikshank, D.P. and Silvaggio, P.M., "Triton, a Satellite with an Atmosphere", *Ap. J.* **233**, 1016-1020, 1979.

Diameter of Pluto

Using speckle interferometry (which gives diffraction - limited spatial resolution inthe presence of atmospheric seeing and telescope imperfections), the diameter of Pluto is shown to be around 4000 km. The surface appears to be covered with methane frost, and the low density suggests Pluto consists largely of frozen volatiles.

The University College, London, Image Photon Counting System was used on the 5 m Hale telescope by the authors of ref. [1] to observe Pluto.

The interpretation of the results depends upon whether or not limb darkening is present, a situation that is suspect due to the synchronously rotation moon, Charon. The surface of Pluto may be mottled. For no limb darkening, the diameter is (3000 ± 400) km. The mass of Pluto, derived from observations of Charon, is around 2×10^{-3} Earth masses and its density from 9.8 to 0.5 g cm^{-3}.

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1. Arnold, S.J., Boksenberg, A. and Sargent, W.L.W., Measurement of the diameter of Pluto by speckle interferometry', *Astrophys* (letters) **234**, L159-L163, 1979.

STARS AND THE INTERSTELLAR MEDIUM

Star formation and Bok globules

Properties of models of collapsing gas clouds are compared with the observed radio and optical properties of Bok globules. It is inferred that these objects have masses of about one hundred times that of the Sun and are indeed collapsing.

Our knowledge of the properties of Bok globules has recently increased due to infrared observations which enable us to see more deeply into the dusty material. The author of ref[1] generated numerically evolutionary sequences of collapsing cloud models. As has been found by other investigators, an off-centre density maximum in the form of a torus develops as rotation slows the collapse and material begins to flow outwards.

The models are compared with observations and, for five of

* Lakehead University, Thunder Bay, Ontario, Canada.

the six globules studied, numerical models were found consistent with the observations.

The ages of the globules are less than one free-fall time, and no globule has reached the stage of rapid flattening and ring formation. The collapse appears to have been triggered by strong external compression.

More detailed observations are needed, and a larger number of globules should be observed at visual, infrared and radio wavelengths.

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1. Villere, K.R. and Black, D.C., 'Collapsing cloud models for Bok globules', *Astrophys* **236**, 192-200, 1980.

The turbulent interstellar medium

Fluctuations in the amount of extinction of planetary nebulae gives evidence of a turbulent interstellar medium. The spatial scale of the oscillations is around 200 pc.

It has previously been suggested that the interstellar magnetic field and electron density are best regarded as random functions of position. The correlation length is 100-200 pc. Data obtained from an analysis of fluctuations in extinction of planetary nebulae are found in ref. [1]to be also indicative of a turbulent interstellar medium with turbulent waves of wavelength of the order of 200 pc.

The observed fluctuations are in good agreement with the model of interstellar absorbing material with mean density decreasing exponentially with galactic height over a scale height of about 100 pc, whose rms density irregularities drop off exponentially over the scale 300 ± 150 pc and which possess an oscillatory component of density irregularity with spatial wavelength about 200 ± 100 pc.

The correlation length estimates of between 100 - 300 pc are confirmed by other observations such as cosmic-ray transport, brightness fluctuations of starlight, variations in polarization of starlight, fluctuations in Faraday rotation and pulsar dispersion measures.

REFERENCE

1. Lerche, 1 and Milne, D.K., 'On the extinction of planetary nebulae and the turbulent structure of the Galaxy'. *Astronom* **85**, 13-16, 1980.

Optical Counterparts of X-ray bursters

X-ray bursters are intense bursts of X-rays, each representing an increase in intensity of 20 to 30 times in half a second, followed by a decay in the intensity for the next 10 or so seconds. These bursts occur about every 5 hours, with the interval between bursts varying by about a quarter of an hour. Faint, blue optical counterparts have been identified with several of the burst sources and investigation of three of these objects indicates a binary system with a low-mass dwarf and an accreting neutron star. The bursts occur as material is accreted.

Using the Richey-Chrétien spectrograph and SIT Vidicon camera as the 4 m telescope at the Cerro Tololo Inter-American-Observatory, the authors of ref. [1] examined three faint, blue optical counterparts of X-ray bursters. The spectra were remarkably similar, with suggestions of high-velocity streams and a rapidly-rotating disc of material. This indicates the neighbourhood of an accreting compact X-ray source, and the observations fit comfortably a model with an accreting neutron star and a low-mass, close, companion.

REFERENCE

1. Canizares, C.R., McClintock, J.E. and Grindlay, J. E., 'A spectroscopic study of the optical counterparts of three X-ray bursters', *Astrophys* **234**, 556-565, (1979).

Models of RS CVn systems

HEAO 1 low-energy X-ray observations of 59 RS CVn systems are analysed and it is concluded that the difference between solar activity and that observed in RS CVn systems is merely a matter of scale.

The RS CVn systems have periods of 1-14 days, a hotter component of type F to GV and a cooler component KO IV, and give evidence of bright chromospheres. Their "photometric wave" is due to dark areas on one hemisphere. These dark areas are similar to sunspots and, by a solar analogy, given an explanation for the enhanced chromospheric activity and predict strong coronal activity.

In ref. [1] the HEAO 1 cosmic X-ray equipment (described in ref. [1] was used to give observations of 59 RS CVn systems. From these observations it is predicted that most RS CVn systems are coronal X-ray sources at a level of about 10^{30} erg s. Models using magnetic confinement of the coronal gas were found to explain the observed emission measurements, pressures, temperatures and variability. The difference between solar activity and RS CVn activity may be merely a matter of scale.

REFERENCES

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2. Rothschild, R. *et al*, *Space Sci. Inst.*, **4**, 269, 1979.

QUASARS

GRAVITATIONAL LENSES

The striking similarities between the twin QSOs 0957 + 561 A, B are explained in terms of a gravitational lens forming two images of a single QSO. The effect of a gravitational lens is discussed.

In ref. [1] it is pointed out that all equivalent widths and redshifts of the emission line features and of the absorption line systems agree to within the errors of measurement, suggesting that a gravitational lens effect is producing twin images of a single source. To test the gravitational lens effect, we need to be sure that double images appear at all wavelengths. We may be able to detect the deflecting mass itself, and from the time-lag in any variations of the two images we could obtain additional information about the nature of the deflecting mass.

A detailed discussion of gravitational lenses is available in ref. [2].

More recent work on gravitational lenses is available in ref. [3], where the problem of the galactic halo acting as a lens is also ocnsidered. Even if a large fraction of the mass in our Galaxy is in a spherical halo of such non-luminous objects as black holes and dead stars, then it is not expected that any noticeable effects will be produced, as the probability of close alignment is low.

REFERENCES

1. Weyman, R.J. *et al*, "Multiple-mirror telescope obser vations of the twin QSOs 0957 + 561 A, B., *Astrophys*, **233**, L433-L46, 1979.

2. Press, W.H. and Gunn, J.E., *Astrophys*, **185**, 397 (1973)

3. Bontz, R.J., "The gravitational lens effect and pregalactic halo objects", *Astrophys*, **233**, 402-410.

Quasars and galaxies

Ten quasars have been found clustered around the companion to the bright spiral galaxy NGC 2639. The redshifts of the quasars range from z = 0.3 to 2.12 while that of the companion galaxy is 0.0056. The cosmological nature of the redshifts is questioned. In a second paper the existence of a 72 kms^{-1} periodicity in redshift intervals is put forward in support of the view that the redshifts is a quantized variable representing some as yet unknown property of matter and/or galaxies.

Ten quasars were discovered around the companion to the bright spiral galaxy NGC 2639. Spectra of the 10 quasars were obtained with the SIT spectrograph at the Cassegrain focus of the 5 m Palomar reflector [1]. At least nine of the quasars are likely to be associated with the companion galaxy. It was found that the quasars often appear in pairs, aligned almost across the galaxy with similar redshifts and properties. Other pairings of quasars across galaxies are known.

The scale on the sky in which the correlations of clusters occurs, and the wide variance of redshifts of the associated quasars, do not seem to be permitted by the heretofore conventional view that all quasars are events in the nuclei of galaxies at large redshift distance. The redshifts of the particular group of quasars considered in ref. [1] do not appear to be due to Doppler velocities.

Another possible reason for not considering quasar redshifts to be cosmological is given in ref. [2]. This work utilizes the set of double-galaxy radio redshifts measured by Peterson [3]. For the 48 pairs with redshift differences less than 500 km s^{-1} it is shown that the characteristic interval of redshift found in major galaxies is close to 72 km s^{-1} in 'velocity' units, with the hypothesis that redshift differences for physical pairs only occurring near multiples of 72 km s^{-1} strongly supported by reservations.

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3. Peterson, S.D., *Astrophys (Supplement)*, **40**, 527, 1979.

BLACKHOLES

Primordial black holes

Limits on the number of primordial black holes, dating from the earliest stages of the expansion of the Universe, are inferred from strophysical observations.

To account for the well-developed structure of the Universe on the scale of galaxies and smaller formations, together with the homogeneous and isotropic large-scale (cosmological horizon) structure, it appears necessary to have small inhomogeneities near the cosmological singularity.

Some of these small perturbations could lead to the gravitational collapse of primordial matter and the formation of primordial black holes with masses ranging upward from the Planck mass [1].

The quantum evaporation of low-mass black holes was discovered by Hawkings [2] and leads to a possible way to detect primordial black holes in the Universe. When evaporating a low-mass (less than 10^{15} g) black hole emits particles and antiparticles - ultrarelativistic electorns and positrons, neutrinos, photons, gravitons, π-mesons, nucleons and other strongly interacting particles. The distribution of particles depends upon the mass. Interaction of the particles with the interstellar magnetic field can trigger a radio-burst, emitted photons can distort the spectrum of the back ground radiation, high-energy hadrons and neutrinos can affect the nucleosynthesis of helium and deuterium in the early Universe.

The observed deuterium abundance can be explained by the presence of a small number of primordial black holes with mass between 10^{10} and 10^{12} g.

Cosmological evidence suggests that black holes evaporate completely or that metric fluctuation on the scale 10^{-33} cm are significantly less than unity.

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RECONSIDERING GALILEO

The Vatican has announced it is reviewing the 347-year old heresy conviction of Galileo, who proved that the Earth revolved around the Sun, contrary to contemporary theology. The Vatican's Secretariat for Non-Believers is looking into the case at the request of Pope John Paul II, as part of an effort to show that modern science and Christianity are not incompatible.

Galileo Galilei, 1564-1642, was condemned as a heretic by the Vatican inquisition office in 1633, and forced to recant his theory under threat of torture. Galileo had published his theory in *Dialogo sopra i due massimi Sistemi del Mondo* (Dialogue on the Two Chief Systems of the World), which contradicted the prevailing Aristotelian theory that the Universe centered on the Earth. The Polish astronomer Nicholas Copernicus (Mikolaj Kopernik) had reached the same conclusion in *De Revolutionisbu orbium coelestium* (On the Revolution of the Celestial Spheres) in 1530, but could not prove it.

Galileo, the first to use the telescope for astronomical research, proved Copernicus' theory. At the time of Galileo's trial, not only were his works placed on the Papal Index (i.e. banned as being "subversive of truth") but also the works of Copernicus and another early astronomer, Johannes Kepler, who suffered the added impediment of being involved in witchcraft.

Among Galileo's other accomplishments were the discovery of four moons of Jupiter (the Galilean moons: Callisto, Europa, Ganymede, Io), which was the first discovery of a satellite other than the Earth's Moon; demonstration of the uneven surface of the Moon; and detection of sun-spots, from which he inferred the rotation of the Sun. His work and methods have led him to be called "the father of modern science."

Legend has it that, at his trial, after denouncing the idea that the Earth moves around the Sun, Galileo added "*E pur si muove*" (Nevertheless it does move). A standard legend since 1761, this statement has since been found on a 1640 portrait of Galileo.

JAMES SWEENEY

SATELLITE DIGEST — 144

A monthly listing of all known artificial satellites and spacecraft. A detailed explanation of the information presented can be found in the January, 1979 issue, p. 32.

Compiled by Robert D. Christy
Continued from February issue]

Name, designation and object number	Launch date lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Orbital Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site, launch vehicle and payload/launch origin
Cosmos 1215 1980-83A 12016	1980 Oct 14.86 10 years	Cylinder? 750?	2 long? 1 dia?	496	549	74.04	95.12	Plesetsk C-1 USSR/USSR
Cosmos 1216 1980-84A 12019	1980 Oct 16.51 14 days (R) 1980 Oct 30	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	193 365 354	387 403 415	72.86 72.87 72.87	90.36 92.25 92.29	Plesetsk A-2 USSR/USSR (1)
Cosmos 1217 1980-85A 12032	1980 Oct 24.45 12 years?	Cylinder-cone + 6 panels?	4.2 long? 1.6 dia?	594 606	40133 39764	62.92 62.92	725.32 718.08	Plesetsk A-2-e USSR/USSR (2)
Cosmos 1218 1980-86A 12039	1980 Oct 30.42	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	170 160 171	353 312 354	64.89 64.89 64.88	89.75 89.23 89.77	Tyuratam A-2 USSR/USSR (3)
FLTSATCOM 4 1980-87A 12046	1980 Oct 31.16 indefinite	Hexagonal cylinder 1884 (fuelled)	1.27 long 2.44 dia	35032	36236	2.46	1428.20	ETR Atlas-Centaur DoD/NASA (4)
Cosmos 1219 1980-88A 12050	1980 Oct 31.50 13 days (R) 1980 Nov 13	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	193 227 237	326 288 321	72.86 72.85 72.86	89.74 89.69 90.14	Plesetsk A-2 USSR/USSR (5)
Cosmos 1220 1980-89A 12054	1980 Nov 4.63	Cylinder?	6 long? 2 dia?	428	444	65.04	93.32	Plesetsk F-1-m USSR/USSR (6)

Supplementary notes:

(1) Orbital data are at 1980 Oct 16.6, Oct 17.1 and Oct 17.9.

(2) Probably an early warning satellite. Orbital data are at 1980 Oct 25.0 and Oct 30.5.

(3) Orbital data are at 1980 Oct 30.5, Nov 10.7 and Nov 11.0.

(4) US military communications satellite providing two way communication between small ground stations, using the 200-400 MHz frequency band. The satellite is located above longitude 172 degrees east.

(5) Orbital data are at 1980 Oct 31.6, Nov 1.8 and Nov 7.0.

(6) Microthruster-controlled reconnaissance satellite, working in conjunction with Cosmos 1167 (1980-21A). Its orbit is such that ground tracks repeat themselves every four days, with those of Cosmos 1220 lying precisely half way between those of Cosmos 1167.

Amendments:

1980-81A, Raduga 7 - add an orbit of 35737 x 35883 km, 0.59 degrees, 1435.90 minutes.

1980-82A, Cosmos 1214 - delete last month's supplementary note. Cosmos 1214 was recovered 1980 Oct 23 after 13 days. Add two more orbits of 165 x 313 km, 67.15 degrees, 89.30 minutes, and 165 x 378 km, 67.16 degrees, 89.96 minutes. Orbital data are at 1980 Oct 10.9, Oct 19.3 and Oct 20.0.

CORRESPONDENCE

We regularly receive compliments from readers about the quality of ideas and opinions which appear in these columns. Do you have a new slant on some topic in Astronautics you would like to express? The Editor is always interested in receiving correspondence for publication. Items submitted should be as concise as possible and because of space limitations the Editor reserves the right to shorten or otherwise adapt material.

Are We Alone?

Sir, I would like to make a few points concerning Mr. Sheaffer's article: "Are We Alone After All?" Firstly the author continually examines the possibilities of other civilizations visiting us from our own somewhat limited technological viewpoint.The College Park Symposium of November 1979 said that "evidence of extraterrestrial activity has not been observed by us". Surely this is a very bold statement as we may not be far enough advanced to be able to observe such activity, nor may we recognise it as such when we do see it. The author writes that alien civilizations may be many thousands of our years ahead of us, and yet still expects them to think and even colonise like we do. Again, he argues that "there are no fundamental obstacles to the colonization of space", but can he honestly say what physical or moral obstacles other races may hold? You cannot expect alien races to act or be like us until we actually meet, and see such similarities. Ronald Bracewell's argument that "history is replete with examples of a more advanced civilization overwhelming and all but obliterating a less advanced one" cannot be applied on a Galactic scale as once again he is guilty of comparing alien thinking to our own.

R. J. ADAMS,
Aylesbury, Bucks.

Naming Celestial Bodies

Sir, Now that the old chestnut of finding names for the supposed tenth planet has, once again, raised its head, may I be allowed to voice one small regret on a previous appelation? Ever since I read an article by Isaac Asimov [1], I always considered the name of 'Prosperpine' as perfect for any Plutonian satellite; because, as Mr. Asimov points out, Prosperpine was Pluto's consort in his underworld kingdom.

In the end, of course, the name of 'Charon' (the underworld ferryman) was picked, which caused some unfortunate confusion with Chiron — the recently-discovered asteroid. Incidentally, Charon was Asimov's choice for the 10th planet.

I think that if I ever pick up the long-awaited 10th planet in my 10 × 50 binoculars one chilly evening, I'll plump for Minerva — the ancient goddess of wisdom; a name, I believe, which was one of several on a short-list, along with Pluto, back in 1930 [2].

RICHARD A. JONES,
Teignmouth, Devon.

REFERENCES

1. Isaac Asimov, *Asimov on Astronomy*, p. 124, Coronet Books, 1976.
2. William Growes Hoyt, *Planet X and Pluto*, University of Arizona Press, 1980.

Vietnam Cosmonaut

Sir, Congratulations are in order to Curtis Peebles for identifying Pham Tuan as the Vietnamese cosmonaut in a letter in *Spaceflight*, November 1979. Tuan's name appeared in Peebles' alternative list. It was an excellent exercise in prediction.

JOEL POWELL,
Calgary, Alberta, Canada.

Satellite Spotting

Sir, The article "The Polyot Missions" by Phillip Clark (*Spaceflight*, September-October 1980) was very interesting. I have made visual satellite observations since 1961. Here are my conclusions on these objects:

1963-43A Polyot 1 payload = cylinder	**1963-43B** Polyot 1 rocket	**1963-43C** Fragment	**1963-43D** Fragment
At first flashing at about 4 sec. Later 26-32 sec; today, mostly steady.	Normal tumbling effect (as other Russian rocket bodies).	Flashing per 0.5-1-5 sec.	Faint, mostly steady.

1964-19A Polyot 2 rocket	**1964-19B** Polyot 2 payload
Not seen/daylight, and then decayed.	Mostly steady, occasional faint flashes. Optical characteristics as Polyot 1.

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SAO — Site 0708,
Federal Republic of Germany.

Chinese "Shuttle" Simulator?

Sir, In the September-October 1980 issue of *Spaceflight*, on page 325, is a photograph of two Chinese astronaut candidates undergoing "training in a space simulator". If this equipment simulates an actual spacecraft, it more closely resembles the cockpit controls of a winged shuttle orbiter-type than the interiors of early US and Soviet manned vehicles. Could it be that the Chinese will bypass the ballistically-recovered "capsule" phase of manned spacecraft technology and go directly for a winged re-usable system for their primary manned space transportation?

DAVID C. KWARE
Wallyford, Pa. USA.

Burner 2: New Details

Sir, I found Andrew Wilson's article on the Burner 2 and 214 upper stages in the May 1979 issue of *Spaceflight* interesting and informative. As far as I know this is the first time that Burner 2A launches have been identified (satellite tables do not distinguish between Burner 2 and Burner 2A and list them all as Burner 2 launches). Also it is the first time that I have seen a photograph published of the Thor Burner 2 launch vehicle.

Upon looking through my files I found additional informance on the Burner 2 upper stages which may interest your readers, and which is given below.

(1) Detailed informative on the solid propelland rocket motors used in the Burner 2 stages is given in [1] and [2], a summary of which is produced below:

	TE-M-364-2	TE-M-442-1
Average thrust (lb)	9680	7745
Burn time(s)	42.2	17.8
Total impulse (lb.s)	418100	142700
Specific impulse(s)	290.4	272.4
Length (in)	52.0	33.04
Case diameter (in)	36.8	26.1
Total mass(lb)	1583	576
Propellant mass (lb)	1440	524
Burnout mass (lb)	131	50.3
Mass Fraction	0.91	0.91

(2) The various components of the strapped-down inertial guidance system of the Burner 2 stage are given in [3] as:
Inverter: 400 Hertz at 26 volts (A.C.)
Programmer: 10 torquing levels.
Velocity meter: Two switches, 0.6 to 20000 ms range.
Flight control electronics.
Gyro reference unit.

(3) The 1967 launch costs for Burner 2 are also given in [3] and are shown below:

Item	Cost (U.S. Dollars)
Stage	246000
Inboard telemetry	32370
Fairing	8000
Ground equipment	150000
TOTAL	436370

(4) The four 22lb thrust control thrusters can be identified as models P/N87481S manufactured by the Walter Kidde Co. [4].

(5) Launch 3 in the launch list is also known as SESP 1, launch 7 is known as SESP 68-1, and launch 13 as STP 70-1 [5].

(6) General Dynamics conducted a study of Burner 2 with the Atlas SLV-3A stage in 1968 [3], [6]. I am not certain whether this is the configuration shown as Atlas Burner 2 in the launch list; the Atlas Burner 2 may have used an Atlas F or E first stage.

(7) Wilson also mentions the launch vehicle used for the Block 5D DMSP satellites. This is a three-stage launch vehicle using a Thor LV-2F first stage, a TE-M-364-15 third stage and an unidentified second stage [7]

STEPHEN P. GRAHAM,
Glasgow, Scotland.

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3. Aerospatiale, Division Systemes Ballistiques et Spatiaux, "Launch Vehicles Data Sheets, Vol. 2: Stages" 5/DEA 5 LD-S-008-0801, Aerospatiale, Division Systemes Ballistiques et Spatiaux, Les Mureaux, April 1973.
4. Specifications, *Aviation Week and Space Technology*, March 1967, p.139-184.
5. Thiokol Corp., "Star 37 Rocket Motor Data", BC296714, Thiokol Corp., Elkton (Maryland), 1976.
6. General Dynamics Corp., "Atlas SLV-314 with Burner 2 Upper Stage", BNZ68-023, General Dynamics Corp., San Diego, 5 April 1968.
7. Mayfield, J., "Weather Satellite Production Continues" *Aviation Week and Space Technology*, 4 June 1979, pp.47-59.

In Honour of Project Daedalus

Sir, "Project Daedalus" is a fascinating report. Although I do not have the background to understand the mathematical and engineering parts, the vehicle configuration and mission profile descriptions were very interesting and enjoyable. I submit that a copy of "Daedalus" (in miniaturized form) be carried on the first interstellar probe and further that one of the sub-probes be named "Daedalus" in honour of BIS.

I feel that other sub-probes should be named after Pioneer and Voyager, the first spacecraft to leave the Solar System, and after scientists interested in interstellar studies today (*e.g.*, Carl Sagan and van de Kamp). A smaller probe could be named "Icarus" after the Solar System/interstellar studies journal.

BIS has shown that interstellar flight is (relatively) close at hand, so that progress in astronautics today (with our help) will bring the day of the first interstellar probe that much closer.

JOEL POWELL,
Calgary, Alberta, Canada.

A few copies of the historic "Project Daedalus" *report are still obtainable from the Executive Secretary, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ, price £6.50 including postage and packing.*

Society's Reputation at Risk

Sir, I note with concern the disorganising activities at the 34th AGM and would like to put on record my complete support for the Council and officers and the high *status quo* of the Society. I hope the Society's professional and scholastic standards will increase still further and not be diluted with demands for other activities, red herrings and digressions.

Any major change in the activities or policies of the Society would soon lead to my resignation and I regret that a reputation built up over decades should be at risk.

DR. DAVID G. HUMPHREYS
Doha, Qatar, Arabian Gulf

To the Executive Secretary:

Sir, I for one acknowledge the terrific pressure you are feeling and must say you're doing a great job for the Society and the members. All the best!

P. N. DICKINS,
Shoebury, Essex.

Sir, Keep up the good work — and I take this opportunity to express my immense admiration for the brilliantly successful way in which Stage 1 was carried out, especially the establishment of the Society's new Headquarters: the effort put into this must have been enormous, and I congratulate you on the outcome, with which you must feel very, very satisfied.

IAN M. HURRELL,
Lymington, Hants.

THE BRITISH INTERPLANETARY SOCIETY
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NOTICES OF MEETINGS

Lecture

Title: **ROLE OF A PRINCIPAL SCIENTIFIC INVESTIGATOR IN SPACE PROJECTS**

by Dr. G. E. Hunt

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on Wednesday, **25 February 1981**, 7-9 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Study Course

Title: **ROCKET TECHNOLOGY**

Eighth lecture: **Sizing of Multi-Stage Rockets** by Prof. I. E. Smith. To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **4 March 1981**, 7 p.m. Course fee is £5.00. Application forms available from the Executive Secretary, enclosing reply-paid envelope.

Film Show

Theme: **EUROPE IN SPACE**

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **11 March 1981.**

Admission by ticket only, available from the Executive Secretary, enclosing a reply-paid envelope.

All-Day Visit

Visit to the **Royal Aircraft Establishment**, on **18 March 1981.**

Registration is necessary. Interested members should contact the Executive Secretary, enclosing a reply-paid envelope.

Lecture

Title: **ASPECTS OF ROCKET PROPULSION**

by M. R. Fry

Venue is the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **26 March 1981**, 7-9 p.m.

Admission by ticket, available from the Executive Secretary, enclosing a reply-paid envelope.

Lecture

Title: **THE INFRARED ASTRONOMICAL SATELLITE (IRAS)**

by Dr. R. Holdaway

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **8 April 1981**, 7-9 p.m.

Admission by ticket, available from the Executive Secretary enclosing a reply-paid envelope.

Symposium

Theme: **SPACE TRANSPORTATION SYSTEMS FOR THE 1990's – Requirements and Solutions**

Offers of Papers are invited for presentation at a one-day meeting to be held in the Golovine Conference Room, Society HQ, 27/29 South Lambeth Road, London, SW8 1SZ on **15 April 1981**, 9.30 a.m. to 4.30 p.m.

Registration forms and copies of the Final Programme will be available from the Executive Secretary in due course. Please enclose a reply-paid envelope with request.

Lecture

Title: **THE PHILATELY OF THE SOVIET SPACE PROGRAMME**

by Rex D. Hall

Venue is the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **29 April 1981**, 7-9 p.m.

Admission by ticket only. Apply to the Executive Secretary, enclosing a reply-paid envelope.

One-Day Discussion Meeting
DAEDALUS IN RETROSPECT

A one-day discussion meeting on Project Daedalus, three years after completion of the study, to be held in the Golovine Conference Room, at the Society's HQ Building, 27/29 South Lambeth Road, London SW8 1SZ on **6 May 1981**, 9.30 a.m.-4.30 p.m.

The Daedalus concept will be reviewed in the light of work appearing since the study, and various areas of investigation stimulated by the Project will be discussed. Offers of short contributions to the discussion should be made to Dr. A. R. Martin, c/o British Interplanetary Society, at the above address.

Members wishing to attend should apply in good time to the Executive Secretary, enclosing a reply-paid envelope.

Film Show

Theme: **THE MAKING OF AN ASTRONAUT**

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **20 May 1981**, 7-9 p.m.

Admission by ticket only, available from the Executive Secretary, enclosing a reply-paid envelope.

Technical Forum

Theme: **THE SOVIET SPACE PROGRAMME**

with contributions by several speakers

Offers of papers are invited. Venue is the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **29 May 1981**, 6.30-9 p.m. No fee is payable but registration is necessary.

Application forms available from the Executive Secretary, enclosing a reply-paid envelope.

Lecture

Title: **SPACELAB**

by Dr. M. J. Rycroft

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **3 June 1981**, 7-9 p.m.

Admission is by ticket only, available from the Executive Secretary, enclosing a reply-paid envelope.

32nd IAF Congress

The 32nd Congress of the International Astronautical Federation will be held in Rome, Italy from **6-12 September 1981**. The theme will be:

SPACE: MANKIND'S FOURTH ENVIRONMENT

BIS members both from the U.K. and overseas, who plan to attend the Congress are asked to notify the Executive Secretary accordingly. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

32nd INTERNATIONAL ASTRONAUTICAL CONGRESS

Rome, Italy, 6 to 12 September 1981

SPACE: MANKIND'S FOURTH ENVIRONMENT

Over the centuries mankind has been concerned, to different extents, with three environments: the geosphere (land), the hydrosphere (oceans) and the atmosphere (air). Technical developments and human achievements during the past decades have progressively emphasised that mankind must also be increasingly concerned with a FOURTH environment: SPACE.

As the IAF 32nd Congress is the last international gathering of space scientists and engineers before the UNISPACE 82 Congress organised by the United Nations in 1982 and falls on the 20th anniversary of the first manned space flight, it has been felt timely and appropriate to devote it to promoting awareness about the challenges and debating the problems posed by the use, further exploration and management of this fourth environment.

The scenario will be set by invited lecturers illustrating the CHALLENGES OF THE FOURTH ENVIRONMENT and by a guest speaker, the Secretary General of the UNISPACE 82 Congress.

The theme will then be developed through a series of symposia and technical sessions organised by the IAF and by the International Academy of Astronautics (IAA), dealing with:

1) the access to and the permanence in the fourth environment,
2) its exploitation and further exploration,
3) its management,
4) the development of the needed soft and hard technologies.

The overall structure of the Congress is shown below:

A UNIQUE HISTORY OF YOUR SOCIETY

"HIGH ROAD TO THE MOON"

Every member of the Society ought to possess a copy of this unique new publication which records many of the Society's original ideas and discussions on Lunar exploration through the visionary drawings of the late R. A. Smith.

The pictures visualise the ideas on orbital rockets, space probes, ships to take men to the Moon and Lunar exploration itself. Some are familiar illustrations, others have never been published before.

Now, Dr. Bob Parkinson has brought these pictures together with a commentary which tells how the Society's pioneers imagined things would be and how they were. But the story goes beyond the present, for man s involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

R. A. Smith, a former President of the Society, died in 1959. He had been one of the pioneers of the Society and left behind him a collection of nearly 150 paintings and drawings which recorded one of the most visionary periods in its history.

The book runs to 120 pages in large (A4) format and about 150 illustrations.

Price £6.00 ($16.00)

Members of the Society wishing to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liaison Committee at Society H.Q. without delay. Papers intended for presentation at the Student Conference must be submitted via the Society.

SPACE: THE FOURTH ENVIRONMENT

Thematic Development	Congress Activities: Name	Type
The Fourth ENVIRONMENT:		
• What it is	CHALLENGES OF THE 4TH ENVIRONMENT	Invited Lecture
• Reaching it	SPACE TRANSPORTATION SYSTEMS	Symposium A
• Staying there	SPACE STATIONS	Technical Sessions
• Exploiting it: the 4 Generations of Peaceful Space Utilization	TELECOMMUNICATIONS	Symposium B
	OBSERVATIONS OF THE OTHER 3 ENVIRONMENTS	Symposium C
	SCIENCE AND PROCESSES IN THE SPACE ENVIRONMENT	Symposium D
	ENERGY FOR AND FROM SPACE	Symposium E
• Exploring it	SPACE EXPLORATION	Symposium F
• Managing it	SPACE CIVILIZATION	
	— Space Economics and Benefits	Symposium G
	— IISL Colloquium on the Law of Outer Space	Symposium H
	— Influence of Space Development on the Humanities	Technical Session
	— Space and Mass Media	Technical Session
	— History of Astronautics	Technical Session
	— Communication with Extra-Terrestrial Intelligence (CETI)	Technical Session
	— Space and Education	Technical Sessions
	— 11th Student Conference	Technical Sessions
• Developing needed technology	SUPPORTING TECHNOLOGIES	Technical Sessions

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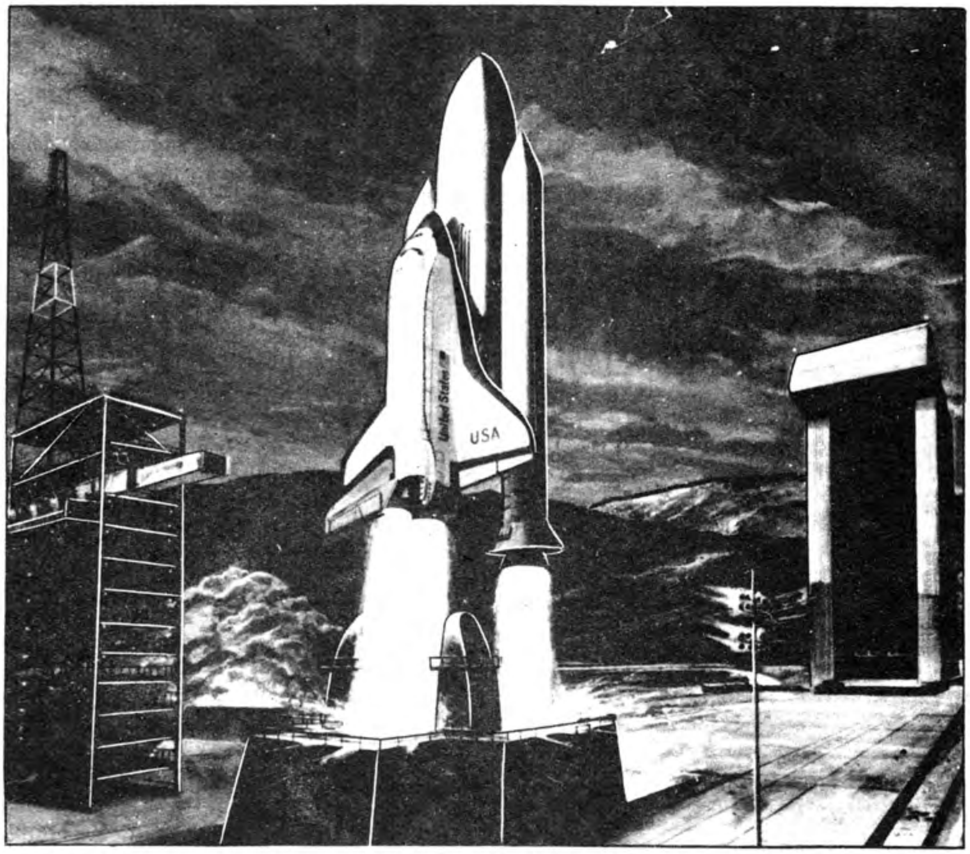
A Space Shuttle blasts off from Vandenberg in this artist's impression. From 1984 many important payloads will be lifted to near-polar orbits including some of the advanced military satellites. One is expected to be the classified US Navy surveillance satellite with active radar for day and night observation of the Soviet fleet.



especially in the summer months. The ocean does, however, keep the temperature from reaching extremes. For ten months out of the year, Vandenberg's average maximum temperature is between 60 and 65 degrees. The lows range from the low 40's to low 50's during the span. September and October are the warmest months, setting themselves apart from the rest of the year with an average high of 69 degrees. Occasions of extreme heat or cold are rare at Vandenberg (Fig. 2).

The beginning of Space Transportation Systems launch operations at Vandenberg AFB will be the product of unprecedented cooperation between the Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA). This is possible because the Space Shuttle is the first truly "national" space programme, involving both civil and military agencies and interests.

Vandenberg AFB was chosen as a site for Space Shuttle launches because of its strategic location and its long history as a missile launch site. Operations at Vandenberg will allow increased payload weight and volume available to polar and near-polar orbits and at a reduced cost per flight compared to existing vehicles. This is practically impossible to do from the Kennedy Space Center (KSC) without expensive energy-wasting dog legs or plane changes to avoid flying over populated areas. There are many existing facilities and support organizations which can be used to support Space Shuttle operations. Vandenberg AFB's large size and relative isolation mitigate in favour of safety and environmental parameters.

Space Shuttle related facilities will be concentrated in two areas on Vandenberg AFB and down the coast at Port Hueneme. Space Shuttle facilities will be concentrated in two areas linked by a 17-mile road.

Extended Runway

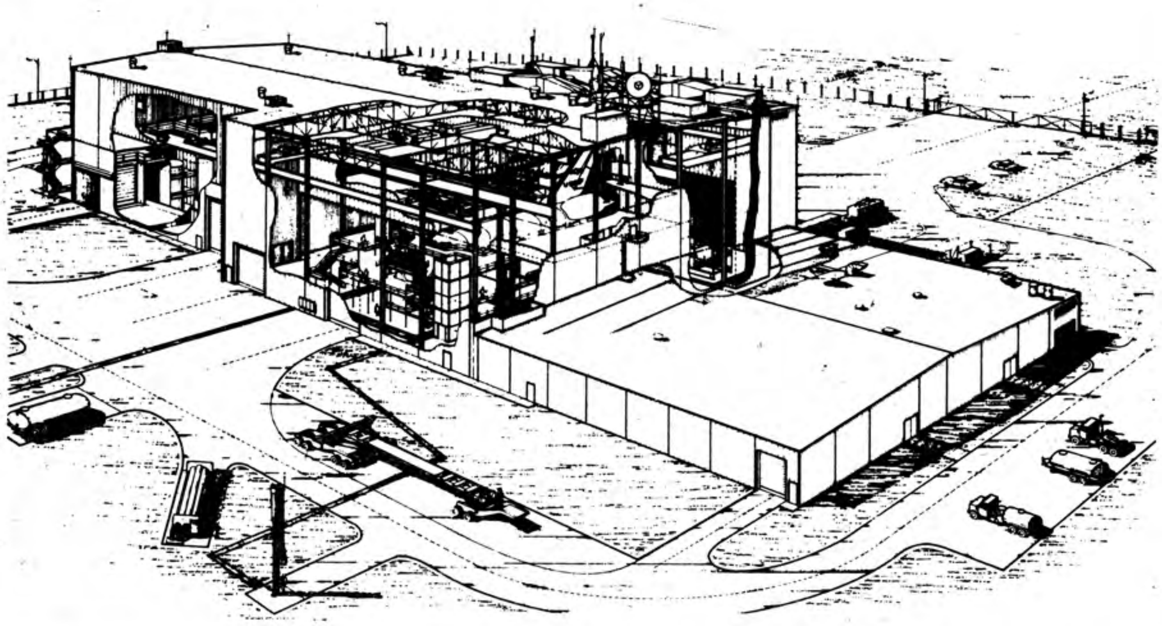
At North Vandenberg an 8,000-ft runway is being extended to 15,000 ft in length. The Orbiter will re-enter the atmosphere under command/control of the Johnson Space Center and make its approach to Vandenberg using the Microwave Scanning Beam Landing System (MSBLS) for a safe touchdown. Also on North Vandenberg AFB is the Parachute Refurbishment Facility (PRF). When the base is fully operational the recovered Orbiter will be towed to the Safing and Deservicing Facility. Initially however the Orbiter will go directly to the Orbiter Maintenance and Checkout Facility (OMCF) after landing.

The OMCF is comparable to the Orbiter Processing Facility at the Kennedy Space Center. It is a 40,000 ft^2 hanger that will house initial post-recovery Orbiter operations and permit two Orbiters to be housed on North Vandenberg AFB at the same time, which will be necessary to meet the 20/year launch rate. In the Safing and Deservicing Facility, the Orbiter will be

Below, artist's concept of Vandenberg showing the location of Space Launch Complex-6. The Southern Pacific Railroad runs through the middle of Vandenberg. *USAF*
LCC, Launch Control Center. SRSF, Solid Rocket Booster (SRB) Refurbishment and Sub-assembly Facility. TCF, Tank Checkout Facility.

Fig. 2

Fig. 3



The Orbiter Maintenance and Checkout Facility on North Vandenberg is a 40,000 ft² (371.6 m²) hanger that will house the Orbiter for post-recovery servicing. *USAF*

supplied with power and cooling to gradually dissipate the heat load of reentry. The propellant and cryogenic systems of the Orbiter will be "deserviced" and purged as needed and ordnance devices safed. Visual inspections are made and the on-board computer data are examined to determine the need for maintenance actions. The Forward Reaction Control System can be removed for off-time maintenance. Finally the Orbiter is towed on its landing gear to the Orbiter Maintenance and Checkout Facility (Fig. 3).

Shuttle Checkout

The OMCF is a 126,000 ft² facility centred around a large hangar flanked by support and payload operations areas. The hangar contains a complex system of fixed and movable platforms which provide access to every part of the Orbiter. Inside the OMCF routine servicing, inspection, and scheduled maintenance can be performed on the tyres, landing gear, crew module, electrical systems, hydraulics and flight controls, and life support systems. It is here that the repair or replacement of damaged tiles of the thermal protection system will take place and the hypergolic propulsion modules can be removed and/or replaced. On-board equipment and mission particular hardware also will be removed and replaced. Many operations of the OMCF and SDF will be accomplished through the use of an interactive computer. The Vandenberg Launch Processing System combines the speed, accuracy, and complexity of the computer with experienced human judgement to efficiently conduct the Orbiter support function.

The VLPS consists of two Checkout, Control and Monitoring Sub-systems (CCMS), one for North Vandenberg located in the Integrated Operations Support Complex, the other for South Vandenberg located in the Launch Control Center. They are sophisticated, interactive systems that monitor, checkout and control the vehicle and support equipment in real time.

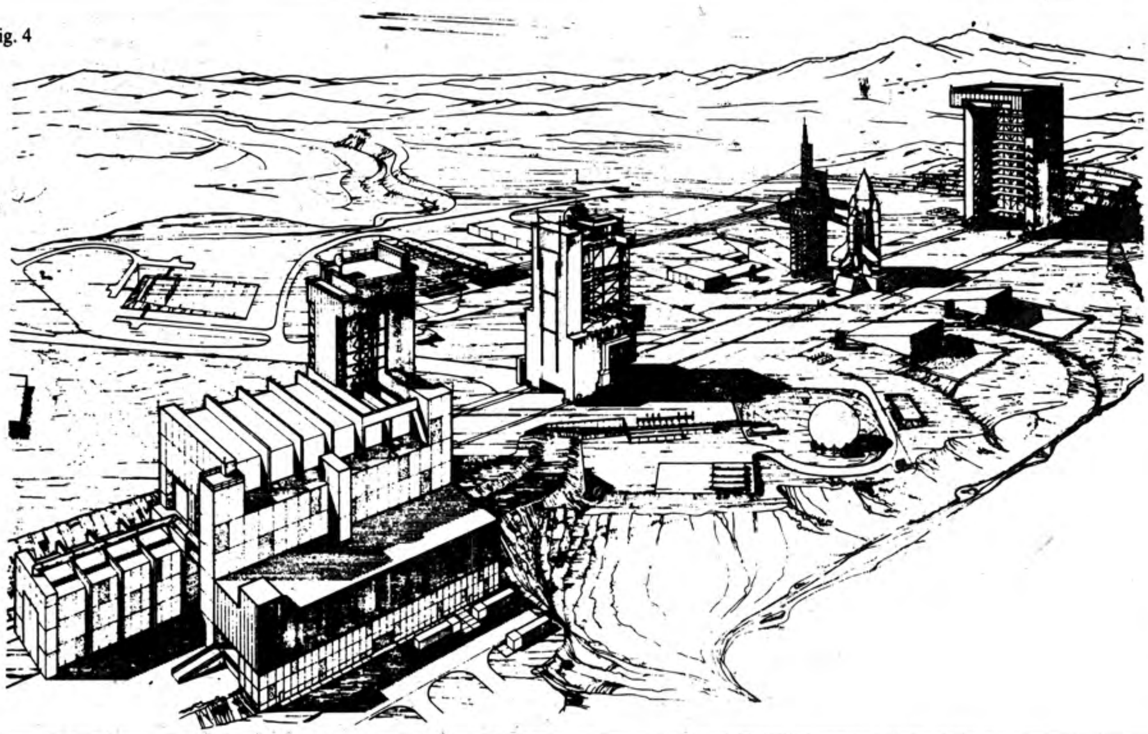
The Central Data Sub-system (CDS), located on North Vandenberg AFB, provides a data bank for Space Shuttle operations, including vehicle configuration, checkout requirements, programmes and procedures for both CCMS, and management and launch data. For classified operations, a Vandenberg Secure Processing System in the Launch Control Center can provide CDS-like functions for South Vandenberg. North and South Vandenberg AFB each has a Recording and Playback System (RPS) to record digital and analog data in real time and playback and display the data for analysis, trouble-shooting and readiness verification.

Once the Orbiter is in the OMCF the payload bay is surrounded by a solid enclosure to ensure stringent cleanliness, environmental control, and security even when the payload bay doors are open. Inside the OMCF the Orbiter is serviced in almost the same way as inside the OPF. But in addition there will be a payload storage area for those payloads, such as Spacelab, that are to be mated horizontally. There will be a Spacelab check-out area and two de-servicing cells for payloads that are returned or retrieved from orbit. The returned payloads, such as a Spacelab or a retrieved satellite, can be attached to a strongback and lifted out of the Orbiter with a 70-ton bridge crane. The payload is then lifted up to the controlled mezzanine linking the hangar and the payload area and transferred to a waiting transporter in the airlock or to a de-servicing area. There, the payload may be rotated to the vertical and installed in a de-servicing cell to permit removal of propellants, safing, de-stacking, or other operations necessary to prepare the payload for transportation from the OMCF. Payloads, such as Spacelab, requiring horizontal installation will be received at the OMCF. The payload areas will be environmentally controlled and will meet strict cleanliness, safety and security requirements.

Installation of Payload

When maintenance is complete and the appropriate payload hardware installed the Orbiter is moved on a transporter from OMCF for the 17 mile trip to SLC-6. In the vicinity of the

Fig. 4



Space Shuttle Launch Complex, Vandenberg Air Force Base, California, *circa* 1984. Assembling the entire launch vehicle at SLC-6 saves the cost of building a new assembly structure similar to the Vehicle Assembly Building at KSC. *USAF*

Launch Pad are the Launch Control Center (LCC) and the Solid Rocket Booster (SRB) Refurbishment and Sub-assembly Facility (SRSF) and the External Tank (ET) Checkout and Storage Facility.

Launch Facilities

A massive Launch Mount will support the Space Shuttle at launch. The Launch Mount has three huge ducts to carry away the exhaust of the SSME's and the SRB's. Each of the ducts are fitted with a high flow rate water system that will reduce the effects of heating and acoustic vibrations. The 315-ft high track-mounted Mobile Service Tower (MST) will be modified to provide access to the Space Shuttle. On the other side of the Launch Mount and opposite the MST are the Payload Preparation Room (PPR) and the mobile Payload Changeout Room (PCR). Next to the Launch Mount is the Access Tower, through which the flight crew will enter the Orbiter.

Colonel Joseph Mirth of the Space and Missile Test Organization gave the major difference of Vandenberg AFB and the KSC as being "... at the launch pad and the way the launch vehicle is integrated. The vehicle will be assembled on the launch pad at Vandenberg, whereas (at the KSC) it is assembled in the VAB (Vehicle Assembly Building) at KSC. Because of the winds blowing very high up there about 90 per cent of the time and we're concerned about this mating sequence out here in the wind, especially on the Point (Arguello)."

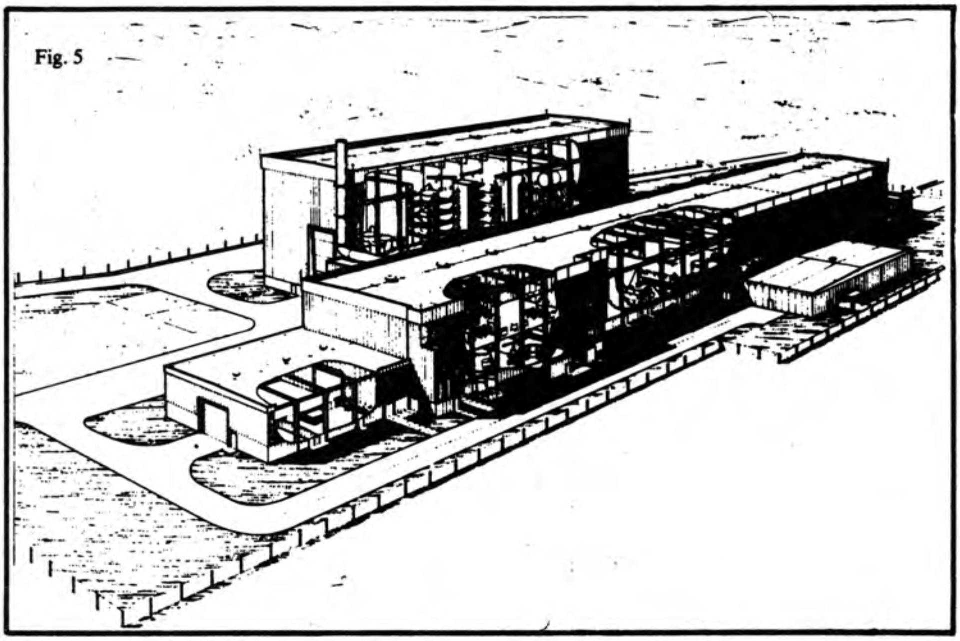
KSC uses an Integrate-Transfer-Launch (ITL) concept, integrating and assembling the vehicle in the existing VAB, and then transferring the entire vehicle to the pad on the Mobile Launch Platform. Considering Vandenberg AFB's low launch rate it would be prohibitively expensive and unnecessary to duplicate the VAB or Mobile Launch Platform.

Instead, SLC-6 will use an Integrate-On-Pad (IOP) concept, where each element of the vehicle is sequentially brought to the Launch Pad, stacked, and integrated on the pad, as is done with expendable launch vehicles at Vandenberg AFB currently. First the SRB's are stacked on the Launch Mount after being brought from the SRB Refurbishment and Sub-assembly Facility (SRSF) in the vicinity of SLC-6. The SRB sub-assemblies are placed on the Launch Mount with the help of the MST crane (Fig. 4).

Next the External Tank (ET) is brought from the Tank Storage and Checkout Facility. The ET is attached to a strongback attached to the PCR by a hinge on the bottom and a

BIRD'S EYE VIEW OF VANDENBERG showing the location of Space Launch Complex-6 (SLC-6). From this pad the Space Shuttle will carry a 32,000 lb (14,515 kg) payload into a polar orbit. In the centre foreground is Tranqllon Point. Beyond is SLC-6 (under construction) and the Launch Control Center. To the south (left) are the facilities for the External Tank. The ET's will be brought ashore at a boathouse from a barge after being shipped from the Martin Marietta plant in Michoud, Louisiana. To the north (right) will be a storage and refurbishment facility for the SRB's. *USAF*

Fig. 5



Artist's concept of the Solid Rocket Booster Refurbishment and Sub-assembly Facility near the launch pad at South Vandenberg. SRB's will be refurbished here following propellant loading at the Thiokol plant in Utah. *USAF*

cable on top. The ET and strongback are then rotated to the vertical position on the face of the Payload Changeout Room (PCR) and lifted into position. The PCR is then moved to the Launch Mount and ET carefully put into place and mated with the SRB's. The ET is released from the strongback and the PCR withdraws to repeat the same operation with the Orbiter, mating it with the ET.

The PCR and MST will be used to gain access to the vehicle for checkout and verification operations, which are controlled by computers in the LCC.

Payload operations at SLC-6 are based on a factory-to-pad concept. A payload arriving at SLC-6 will enter the Payload Preparation Room (PPR), be removed from its transportation, and inserted into one of three payload preparation cells. Limited assembly and checkout operations can thus be conducted on several payloads while the Orbiter is being prepared on the pad. This provides for payloads that require longer preparation times than the interval between launches. For safety reasons, the PPR is located far enough from the Launch Mount and constructed to protect delicate payloads from damage by hock, blast, or acoustic vibrations. The payload cells are isolated for security and provided with stringent environmental cleanliness and controls.

The payload is moved out of its cell when it is ready for integration with the Orbiter. It is lifted into the PPR tower and the Payload Ground Handling Mechanism is attached to the payload and, with the payload, is transferred to the mobile Changeout Room. The PCR moves on its tracks to the vehicle and rests against the Orbiter. The Orbiter payload bay doors and the PCR doors are closed and the PCR withdraws.

As the final preparations for launch draw to a close the MST rolls back from the Launch Mount. The flight crew enters the Orbiter by way of an access arm. The loading of the liquid oxygen and liquid hydrogen is begun at about T-2 hours. In the final moments before launch the crew access arm retracts and control is transferred to the Orbiter's on-board computers. As the vehicle lifts off, operational control transfers from Vandenberg AFB to the Mission Control Room at the Johnson Space Center.

At lift-off a recovery ship and a companion tug will be waiting on station as the SRB's burn-out, separate from the ET, and parachute into the ocean. The ship will locate the SRB's and begin the recovery process. The SRB's undergo the same sort of processing at the KSC, except that this facility will be located at Port Hueneme, midway between Los Angeles and Vandenberg AFB. The recovery ship will guide a remotely controlled, self-propelled plug into the nozzle of the vertically floating SRB, where it seats and forms an air-tight seal. Air will then be pumped into the chamber and the water forced out until the booster translates into the horizontal position. A towing harness is attached and the booster is transferred to the tug, which tows the SRB to Port Hueneme. The recovery ship picks up the parachutes and locates the second SRB. The operation is then repeated.

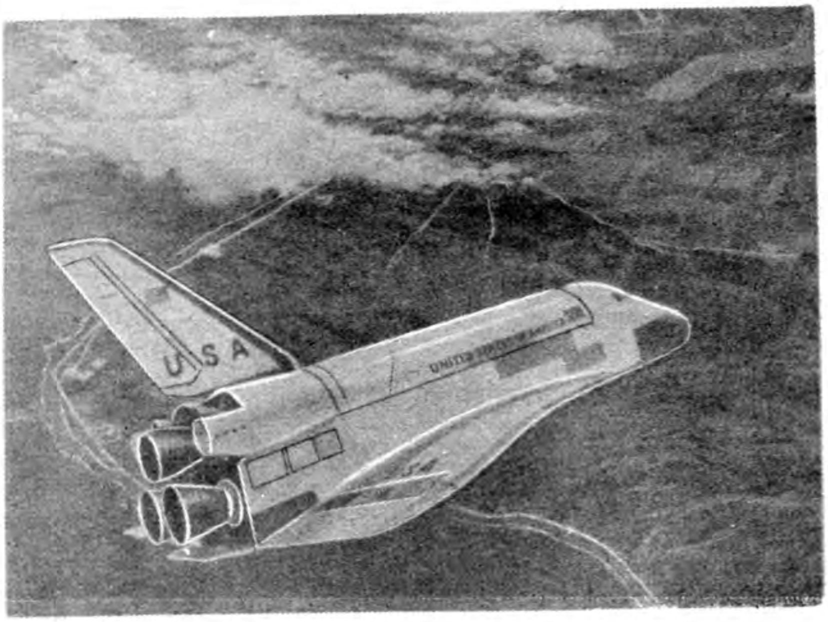
At Port Hueneme the SRB's are lifted out of the water by a straddling crane and placed on special rail cars. The SRB's are then thoroughly cleaned and residual propellants removed. The SRB's are disassembled and shipped by rail to the Thiokol Corporation in Ogden, Utah. At the Parachute Refurbishment Facility on North Vandenberg the parachutes are washed, dried, repaired and repacked.

SRB Refurbishment

There are other systems and facilities that play a vital part in Space Shuttle launch operations at Vandenberg AFB. On South Vandenberg, near to SLC-6, is the SRB Refurbishment and Sub-assembly Facility (SRSF) where all SRB operations are conducted. The 121,000 ft² SRSF permits storage and preparation of the SRB segments when they arrive by rail from the manufacturer in Utah. All other SRB components are inspected, checked out and repaired in the SRSF. Each sub-assembly of the SRB is transported to the Launch Pad on a rubber-tyred transporter.

The ET's will be delivered by a NASA barge from Michoud to the Vandenberg boathouse. This makes use of the shallow harbour at South Vandenberg AFB. The ET's will be towed from the boathouse to the Tank Checkout and Storage Facility (TCF), which has four storage cells and one checkout cell. The tanks are stored and monitored until needed, then a simple checkout is performed to verify that the ET is ready for flight. Then it is transported to the Launch Pad for mating with the SRB's.

The Military Construction Programme for 1979 included preparation of paper plans and the initiation of construction activities on SLC-6. Late in 1979 the demolition and preparation phases had been completed. Construction of the



Shuttle Orbiter approaching landing site at North Vandenberg. Launch and landing operations are scheduled to begin in 1984.

USAF

major facilities, such as the Launch Mount exhaust ducts, Access Tower, and Payload Preparation Mount, is now underway. Part of the VLPS, the Central Data Sub-system, is operational and being used for software development. Construction of the Orbiter Maintenance and Checkout Facility has also begun.

Vandenberg AFB is currently in the first phase of its development which entails facility design through 1981 and the construction phase through 1983. Phase I preparations will be capable of supporting six launches a year. Phase II entails the installation of support equipment and software. This stage would be capable of supporting a 20 launch/year rate.

According to Col. Mirth, "There are a host of facilities that we (the US Air Force) have to build around Vandenberg because of power requirements, roads and bridges and so on. We are working very closely with SAC, the host organization at Vandenberg to come up with a proper base of support. There will be a significant increase in the population at Vandenberg, especially during the construction period. We have to work closely with the Range Operations people .... Of course we have the Systems Management Office at the Space Division and we also have the Space and Missile Test Organization (the old SAMTEC organization) at Vandenberg that will be responsible for processing the vehicles as they progress through Vandenberg and pretty close NASA support. They will have a cadre of NASA people working very closely with us."

A great deal of the support for Vandenberg Space Shuttle operations will be provided by the First Strategic Air Division. On-site technical management of Space Shuttle operations on Vandenberg will be the task of the 6595th Shuttle Test Group, part of the Western Space and Missile Center. The 6595th will oversee all the Space Shuttle contractors on Vandenberg AFB and coordinate operations.

Vandenberg is well prepared for its role as America's most versatile and active aerospace launch center. Vandenberg's 98,400 acres contain a modern 125-bed hospital, an airport, warehouses, a theatre, restaurants, supermarkets, its own bank and business establishments, schools, recreational facilities, industry, miles of roads and railroad sidings, and everything needed to support a thriving community.

The future World

The new construction at Vandenberg is one indicator that man is now in space to stay. Man will have conquered and tamed space, putting it to his own use. The US Air Force facilities at Vandenberg will be a vital part of this new era in space. The Space Shuttle Transportation System will evolve toward an On-Demand Launch System. That is a vehicle that can be over any point on Earth in less than an hour of launch and perform multiple missions.

Through some important extrapolations and generalizations it is possible to describe some of the major characteristics of the future world. There will be a continued decrease in natural resources of all kinds but principally energy, minerals, water, and arable land. The world population will increase, especially in the third world countries. This will increase their needs and the competition for resources and influence. The spread of armaments throughout the world will continue, whereby Vietnam, Libya, Iraq, India, the People's Republic of China, and Israel become even more significant power centres in addition to the USSR and European nations.

The decrease in global natural resources and the increase in world population and needs portend the increased potential for conflicts between the major and minor powers. Coupled with this, the increased numbers of arms possessed by a growing number of nations make such conflicts almost inevitable. This dictates the requirement for a quick reaction to an increasing number of crises around the globe.

According to Morgan Sanborn of Rockwell International, a former US Air Force Colonel, "... we need space superiority to allow space operations in a crisis or wartime situation, surveillance and warning of whatever the enemy might be doing. Knowledge of an adversary's system. I feel in the time frame of the middle 90's or the year 2,000 that we should have a satellite inspection capability and an anti-satellite."

An On Demand Launch System could be a strong force for peace. Former President Carter declassified "the fact of" space-based photo-reconnaissance systems. These systems are the key to verification of the SALT II Treaty. An even more interesting concept is "Satellites for Peace" proposed by Senator Adlai Stevenson. According to this plan the US would provide information on what is going on around the world militarily to the rest of the world. In the view of the Senator such a system would preclude military adventurism.

A truly operational On Demand Launch System will need aircraft operation and maintenance. There are many considerations for such launch systems and propulsion modes. They include single-stage-to-orbit, multi-staged reusable vehicles, stage and a-half, expendable boosters with recoverable spacecraft, siamese/triamese vehicles, and others in seemingly all possible combinations of horizontal and vertical take-off and landing modes.

T 10

31st CONGRESS OF THE INTERNATIONAL ASTRONAUTICAL FEDERATION

By Professor Peter M. Bainum*

Introduction

The 31st IAF Congress with the general theme "Applications of Space Developments" was the first IAF Congress to be held in the Far East. Thirty countries were represented with 415 delegates from abroad and 285 delegates from Japan. The venue was in the modern Takanawa Prince Hotel, Tokyo, between 21-28 September 1980. As in past Congresses the agenda of technical sessions was crowded; one had to make a selection between five or six simultaneous technical sessions and with the last minute cancellations or presentations by substitute speakers, session hopping proved to be extremely difficult.

Holding the Congress in Japan proved to be a resounding success both from the standpoint of Asian participation in the IAF (e.g. approximately 80 Japanese papers were listed), and also from the point of view of letting the world take a look at space developments in Japan (for the first time a whole afternoon during the conference and all day Sunday immediately following the conference were devoted to technical field trips). Participants chose between four separate afternoon trips to the Japan Broadcasting Center, or the National Aerospace Laboratory, or the Radio Research Laboratories, or the Institute of Space and Aeronautical Sciences of the University of Tokyo. The all-day trips featured visits to:

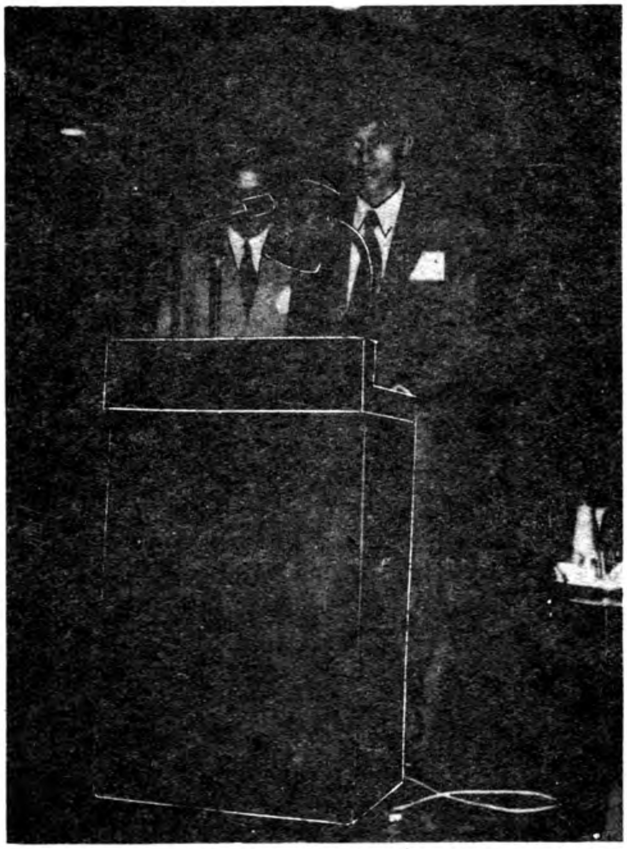
(a) The Kashima Experimental Earth Station; or
(b) the Tsukuba Space Center of NASDA; or
(c) a combined visit to the Japanese Earth Observation Center (LANDSAT station), the GMS Command and Data Acquisition Station, and the Meteorological Satellite Center.

The Japanese host organizations included: the Japan Society for Aeronautical and Space Sciences; the Institute of Electronics and Communications Engineers of Japan; the Japanese Rocket Society; the Japanese Astronautical Society; and the Space Activities Promotion Council of Keidauren under the chairmanship of Masao Yoshiki, of the Congress Organising Committee. Mr. Yoshiki is also the Acting Chairman of the Space Activities Commission of Japan.

Opening Ceremony

The opening ceremony included speeches by: Mr. Yoshiki, by Kimitomo Takahira, Japanese Parliamentary Vice-Minister for Science and Technology; by Prof. D. Mori, President of the Japan Society for Aeronautical and Space Sciences; by Mr. A. Padang of the U.N. who read a brief address on behalf of Peter Jankowitsch, Chairman of the U.N. Committee on the Peaceful Uses of Outer Space; and finally by Mr. Roy Gibson, outgoing President of the IAF.

The invited lecture on "The Economic Effects of Space Activities" was delivered by Michel Bignier, Manager of the Spacelab Program, ESA, at the opening ceremony. Bignier defined the economic profit of a system as measured by the comparison between the development and implementation investment costs and the profit derived from the service made available. While this parameter can be determined with relative accuracy for certain national telecommunications systems, Mr. Bignier acknowledged the difficulty in extending this concept to other space systems such as those devoted to earth resources and meteorology.



Some of the most interesting presentations during the Congress were by Soviet cosmonauts and their colleagues from Intercosmos. *Top, left to right,* V. Kubasov, G. Ivanov (Bulgaria), V. Kovalyonok, V. Aksyonov and Pham Tuan (Vietnam). *Bottom,* Pham Tuan (right) tells of his experience during the Soyuz 37 mission to the Salyut 6 space station.

* *Department of Mechanical Engineering, School of Engineering, Harvard University.*

Top, Cosmonauts Kubasov, Ivanov, Kovalyonok, Aksyonov and Pham Tuan answer questions from the floor. They told of their great enthusiasm for manned space flight which was making major contributions to science and technology and the world's economic development. *Bottom,* cosmonaut Kubasov signs autographs for Congress participants. *Photographs: Iwao Eto*

Economics of Space Technology

The economic effects of space developments were discussed by four invited speakers at a forum held immediately following the opening ceremony and organized by D. E. Koelle (FRG) and B. N. Petrov (USSR), who recently and unexpectedly passed away one month prior to the Congress. Dr. Santiago Astrain, Director General of INTELSAT, in a well prepared paper, indicated that by 1985 as many as 97 communications satellite systems would be either in operation or in the planning stages throughout the world. The communications satellite electronics and aerospace industry already represents a $2 billion annual activity worldwide. Dr. Klaus Heiss and William Good of ECON, Inc., USA, described the benefit to cost ratio of the LANDSAT operations system as between 4.3 and 9.3, with the current benefits in the annual range of between $2.26 and $4.92 billion. In the following paper, Dr. M. Curien, CNES President, emphasized the many different methods of evaluating cost performance of research and development expenditures, which lead to enormous differences in economic statistics. "Space and Energy" was the final forum topic addressed by Dr. George E. Mueller, President, SDC (USA). Dr. Mueller described much of the Solar Power System work completed to date as being "highly speculative". In order to place the SPS into a geosynchronous orbit a total launch vehicle payload capacity of 380,000 kg. would be required.

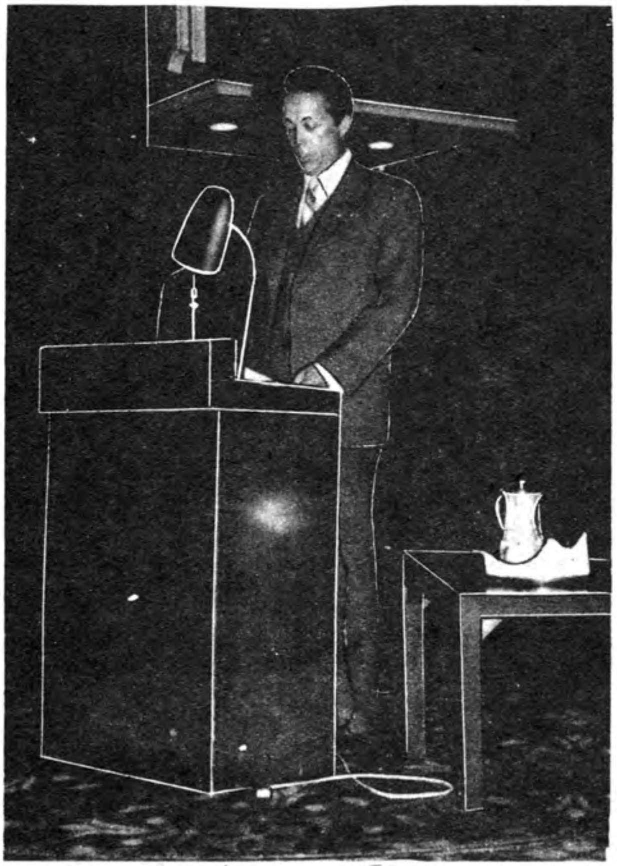
Scientific Sessions

After the completion of the forum session the scientific sessions commenced and continued throughout the balance of the week — often six simultaneous sessions were offered so that one had to make a careful choice in advance. Due to last minute cancellations and unscheduled papers appearing — even in the middle of a session — it was extremely difficult to alternate between the different sessions. A few observations follow, reflecting the interests of the writer.

(1) The number of Astrodynamics sessions was increased to four showing an increased activity in this field after several years of decline (this tendency has also been noted within national meetings in the USA); (2) the two sessions devoted to Large Space Structures (Structural Technologies and System Fabrication and Assembly) reflect the increased interest in the development of this technology for a variety of future missions including large scale communications, earth resources, electronic mail systems, and space based power generation. Average attendance at these sessions was between 75-100, among the best attended of the specialty sessions. Although the majority of the papers offered were from the US, three Japanese and three Italian papers were also presented in addition to a single paper from the USSR; (3) a total of five technical sessions on Communications Satellites properly reflect the scientific and commercial interest shown in existing and proposed space-based communications systems.

Special Interest Sessions

The IAF Congress has always contained a number of special-interest symposia organized by the International Academy of Astronautics and this year the trend was continued. Included were: the 10th International Symposium on Space Economics and Benefits; the 9th International Review Meeting on Communication with Extra-terrestrial Intelligence (CETI); the Scientific-Legal Round Table on Large Systems in Space; the 13th International Space Rescue and Safety Symposium; and the 14th International History of Astronautics Symposium. In addition, the 23rd International Colloquium on the Law of Outer Space, organized by the International Institute of Space Law, contained four different sessions with topics ranging from the 1979 Moon Treaty, to the legal aspects of the environment, remote sensing, and the international construction, operation, and ownership of large space structures.



Above, Cosmonaut Aksyonov explains the operation of the new Soyuz T spacecraft which, he said, was highly automated and could be flown independently of ground control, either manned or unmanned. The orbital module, which on the standard Soyuz jettisons after retro-fire, is cast off in orbit to save fuel.

Photograph: Iwao Eto

Below, at the XXXIth IAF Congress reception, 22 September 1980. Roy Gibson (BIS Fellow, IAF Past-President and former Director-General of ESA) helps M. Yoshiki, Chairman, Congress Organising Committee, break open a cask of saki (rice wine.) *Extreme left,* S. Saito, Vice-President IAF. *Extreme right,* I. Hitaki, Executive Director, NASDA.

IAF General Assembly Tokyo 26 September, 1980

The Nominations Committee appointed by the General Assembly on 22 September 1980, was composed as follows: R. Akiba (Japan), H. Fischer (DDR), A. Jaumotte (Belgium), K. B. Serafimov (Bulgaria), **W. H. Stephens (UK)**. M. Bourely (IISL) acted as convener of the Committee.

The recommendation unanimously adopted by the Committee and addressed to the General Assembly through the Bureau is that the Bureau of the IAF for the coming year be composed as follows:

President:	L. Perek (Czechoslovakia)
Past-President:	**R. Gibson (UK)**
Vice-Presidents:	M. Chevalier (France)
	J. Grey (USA)
	D. Mishev (Bulgaria)
	R. Monti (Italy)
	Daikichiro Mori (Japan)

Separate evening sessions featured the following four current events: the Japanese Launch Vehicle Development; the Soyuz-Salyut Program Review; the Ariane Launch Vehicle; and the Space Shuttle Program. Perhaps the highlight of these sessions was the firsthand account of the Salyut-6 Soviet manned research station as presented by the following five cosmonauts: Dr. V. Kubasov, USSR; Lt. Col. G. Ivanov, Bulgaria; Col. V. Kovalyonok, USSR; Dr. V. Aksyonov, USSR; and Col. Phan-Tuan of Viet Nam (who provided his own translator, separately from the first four). The flight of Salyut-6 was illustrated to a packed audience by means of an unedited, soundless film which was narrated live by Dr. Kubasov after detailed verbal reports by Drs. Yu. P. Semenov and V. Legostaev, Technical Director and Deputy-Technical Director, respectively, of the Salyut Development Programme.

Unscheduled Activities

In addition to the very intensive technical and social program the visitors were also "rewarded" in the early morning hours of two consecutive days by a series of seismic activities the most serious of which occurred about 3 a.m. on Thursday — an earthquake with an intensity of 4.5 on the Richter scale in the Tokyo area (and 5 at the epicenter) and whose final aftershocks continued until after 6 a.m. Those of us who were enjoying panoramic views from the upper floors of high rise hotels will never forget the various induced lateral oscillations of the contents of their rooms followed by the distinctive vibrations of the aftershocks — a true testimonial to the margins of safety designed in these structures by the Japanese architects and engineers. During a sightseeing tour later in the week, we were informed that the famous Tokyo Tower was the "only earthquake resistant structure" in the entire city of Tokyo, but does not accommodate overnight guests!

Rome Congress

Preparations are already underway for the 32nd IAF Congress to be held in Rome from 6-12 September 1981. Professor Paolo Santini, Chairman of the Organizing Committee, indicates that all scientific sessions will be held in the Faculty of Engineering Building of the University of Rome, and that as a part of the general programme he is trying to arrange a special audience with the Pope. This will mark the first congress where the Chinese Society of Astronautics (Beijung) will represent China as the voting member society, in accordance with a vote taken by the IAF General Assembly at the Tokyo conference. The nomination of Dr. Lubos Perek of Czechoslovakia as the next IAF President was unanimously approved by the General Assembly. Dr. Perek replaces Roy Gibson of the UK who has completed a two year term as the IAF chief executive.

BIRTH OF THE UNIVERSE

A NASA scientist has found possible new evidence suggesting that the subatomic particles known as neutrinos have mass, and that our Galaxy may be surrounded by vast numbers which were produced during the first few moments of the birth of the Universe. Until recently, neutrinos were thought to have no mass, like photons.

Dr. Floyd W. Stecker, of the Laboratory for High Energy Astrophysics at the Goddard Space Flight Center, says there may be new astronomical evidence based on a recent suggestion by CERN (Center European De Recherche Nucleaire) physicist A. de Rujula and Nobel Laureate Sheldon Glashow of Harvard University that if neutrinos have mass, evidence for their decay might be found in ultraviolet astronomical observations.

Dr. Stecker, writing in the October 27 1980 issue of *Physical Review Letters*, concludes that tentative evidence of a spectral line, which may be from decaying neutrinos, exists near the ultraviolet wavelength of 0.00017 mm in various rocket observations.

Ultraviolet astronomical observations can only be made above the Earth's atmosphere, with rockets and satellites. Dr. Stecker used rocket observations by Dr. Richard Henry of Johns Hopkins University and his collaborators as well as observations of a French group working with data from the French D2-B spacecraft. Future ultraviolet astronomy studies, providing more refined observations, are needed in order to further test the neutrino-decay hypothesis.

The hypothesis, if it is correct, holds important implications for theories dealing with the nature of all matter and the ultimate fate of the Universe.

The strength of emission lines from ultraviolet spectroscopy gives important evidence on the rate of decay, which in turn is inversely proportional to lifetime. Dr. Stecker believes that if his interpretation of the ultraviolet data is correct, these neutrinos live so long that only one neutrino in 10 million would have decayed since the Universe began (under the Big Bang theory of cosmic evolution. *Ed*).

According to the Big Bang theory, all of the matter of our present universe was originally packed together in a primeval fireball — an extremely hot, dense ball that exploded about 15,000 million years ago. The gigantic explosion threw hydrogen, helium, electrons and radiation out into space. The matter that was spewed into space expanded and cooled, and several million years later, it condensed into galaxies. The Universe has continued to expand, and the galaxies have continued moving away from each other ever since.

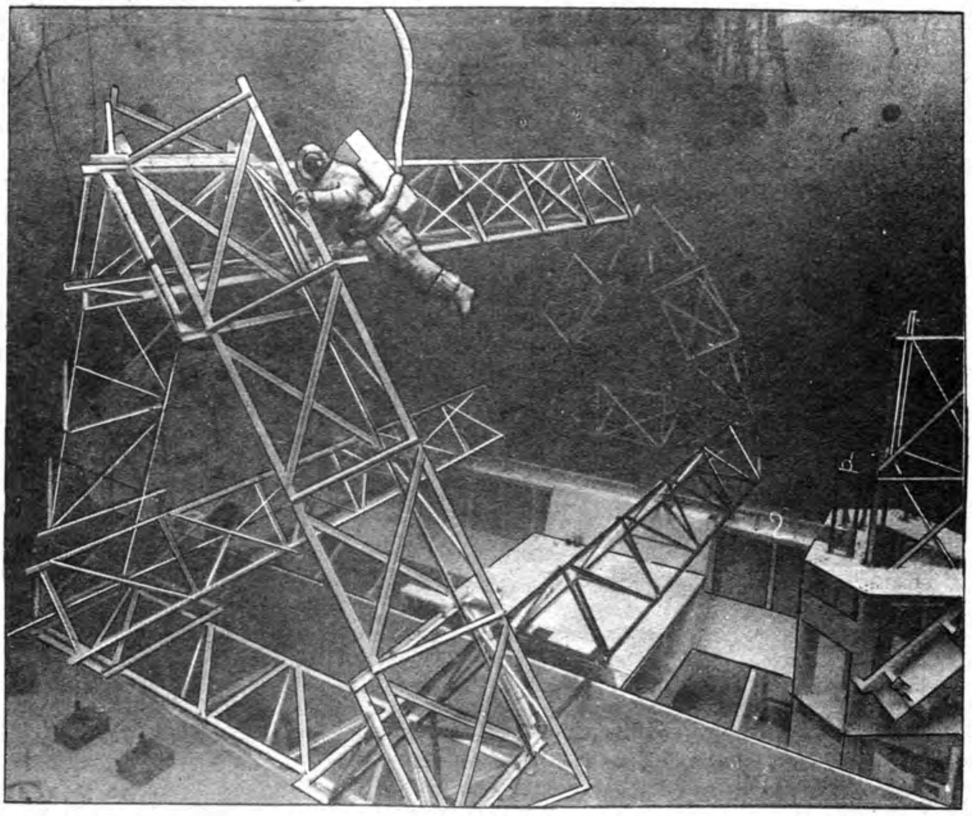
One part of the Big Bang theory states that there are roughly 1,000 million neutrinos for every proton in the Universe. (Protons are the nuclei of hydrogen atoms, which account for 90% of the atoms in the Universe.) Our Galaxy may be surrounded by a spherical sea or "halo" of neutrinos which were created in the first moments of the Big Bang, some of which are decaying all the time.

If Stecker's conjecture is correct, the "heavy" neutrinos which produce this spectral line at the observed wavelength would weigh so little that it would take 1,000 million of them to equal the weight of one nitrogen atom. However, there are so many of them that they would make up the bulk of the mass of the Universe and account for the mysterious "missing mass" in large clusters of galaxies.

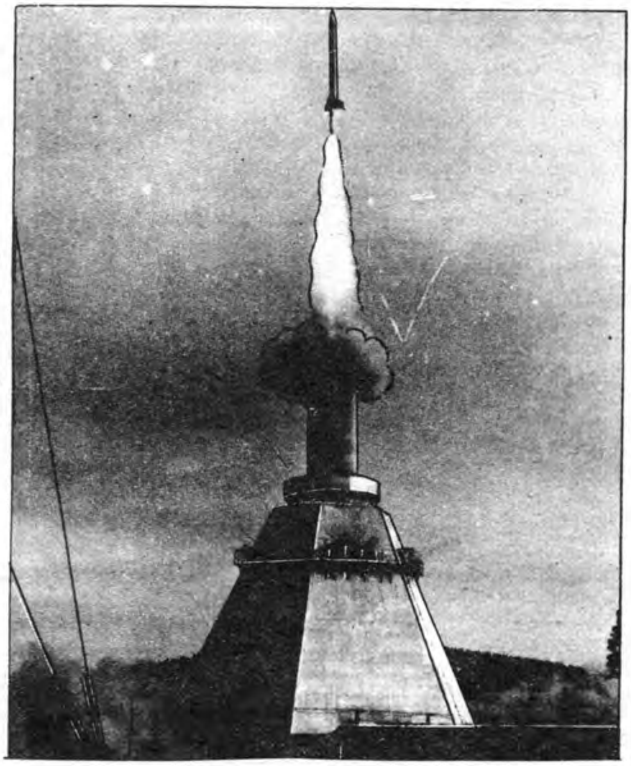
Stecker's mass estimates agree with recent reports by a group at the Institute for Theoretical and Experimental Physics in Moscow.

Other recent evidence for neutrinos having mass has been reported by a group at the University of California at Irvine under Dr. Frederick Reines.

The determination of the fundamental properties of neutrinos, such as their mass and lifetime, provides important clues to understanding the nature of all matter. In addition, the exact determination of the masses of all types of neutrinos (of which three are presently known) will enable astrophysicists, using the general theory of relativity, to deduce whether the Universe will keep on expanding forever or will eventually collapse, producing a new Big Bang.



LEARNING TO USE THE BEAM-BUILDER. Using beams spun out of spools of flat aluminium by an automated beam-builder, a mockup of which is shown at right, space-suited engineer Stephen Hall assembles a triangular prism in simulated conditions of weightlessness in the 1.3 million-gallon Neutral Buoyancy Simulator at the Marshall Space Flight Center, Huntsville, Alabama. Some day astronauts may use such a beam builder carried aboard the Space Shuttle to assemble large structures in orbit. In this test, Hall is shown taking beams from a simulated beam machine located in the Shuttle cargo bay mockup and assembling them outside the bay.
NASA



SKYLARK IN SWEDEN. One of four BAe Skylarks launched to date from Kiruna in Arctic Sweden in the German Space Agency's (DFVLR) programmes of scientific research into the upper atmosphere and into the investigation of materials behaviour under micro-gravity conditions. ***British Aerospace***

MORE SKYLARKS FOR 'TEXUS'

Germany is forging ahead with "space factory" experiments using British Skylark 7 research rockets. Another order worth £450,000 has been placed with British Aerospace for five rockets to be launched from Kiruna, Sweden, between 1981-1983.

The experiments are part of the German Texus project designed to obtain early experience in making materials under weightless conditions in space. Already three Skylarks have been launched with success.

So far no similar tests have been ordered in Britain.

SCIENTISTS DEFY GRAVITY

Scientists at the Marshall Space Flight Center in Huntsville, Alabama are experimenting with the use of sound waves to make small objects defy gravity.

The process, called acoustic levitation, could revolutionise the way in which materials are processed aboard spacecraft, and may ultimately result in improved products for use on Earth.

"The concept of processing materials in the weightlessness of space is not a new one," explained Richard E. Black, an engineer with Marshall's Materials Processing in Space Project Office. Experiments were conducted aboard Apollo and Skylab missions where glass or metal was melted in a furnace, processed into a new or better substance, and then solidified through cooling. What is new is the technique of "containerless processing," where the material is suspended in an open area within the furnace and processed without touching or being touched by the contaminating walls of the furnace or other container. Therein rests the potential value of acoustic levitation.

While a levitator would not be needed in space to counteract gravity, it could be used as a positioning device to control the movement of the free-floating material while it is being processed.

The Marshall Center is now testing a single-axis acoustic levitator, built by Intersonics Incorporated of Chicago, for use on the Space Shuttle. The levitator consists of a vibrator which directs high frequency sound waves against a ceramic reflector that bounces them back to create a balanced "energy well" between the source and the reflector. After the furnace is activated, the material sample to be processed is injected into the energy well where it remains suspended while going through the melting, mixing and cooling cycle.

Aboard the Shuttle, the experiment using the levitator will be housed in a 36 in^3 (540 cm^3) furnace which will reach a temperature of nearly 3200°F (1600°C). The device will be used in the experimental processing of advanced optical glass.

"The potential value of containerless space processing is the ability to produce purer materials such as optical glass for telescopes and microscopes," said Mr. Black.

The experiments scheduled for the Shuttle are follow-on projects to acoustic levitation and other containerless processing experiments being conducted on Earth and aboard sounding rockets.

GROWING COLLAGEN IN SPACE

A study to explore the possibilities of processing collagen in space is being offered to companies by Battelle's Columbus Laboratories. Collagen, which in its natural form makes up 35 percent of the protein in body tissues, also forms the primary structures of tendons, nerves, skin, bones, and blood vessels. Processed collagen shows promise as a material for producing membranes and prostheses used in medicine and surgery to replace or repair damaged human organs.

"Unfortunately, for many applications collagen cannot be produced to the desired uniformity in the Earth's environment," according to Battelle's Kenneth E. Hughes, who heads the study. "However, it appears quite likely that a homogeneous gel can be made in space."

As part of the 42-month study, being offered to a number of companies who would share in the costs and benefits, Battelle will experiment with growing collagen aboard the Space Shuttle. Pioneering experiments have already been launched to demonstrate the feasibility of collagen reconstitution in space.

The Shuttle experiment will be conducted in a self-contained payload weighing less than 200 lb and occupying less than five cubic feet of space.

Between now and the experimental flight — expected to be in 1982 — Battelle researchers will conduct ground-based studies and will design equipment to be used in the flight. Within 12 months an automated collagen processing facility (ground-based) will be ready for demonstration.

Work has already begun on the study of normal and high-gravitational-force effects on this process. Comparison of ground-based and space flight data will demonstrate the true effects of gravity on the collagen reconstitution process. Homogenity should be achieved, proving the feasibility of manufacturing uniform collagen materials in space. The experiments are also expected to yield a better understanding of basic collagen fibril formation.

Battelle hopes the Shuttle flights will lead to new and useful products for many clinical applications. It is possible that a family of biomaterials based on collagen could be developed for use in opthalmology; burn treatment; drug delivery; and cardiovascular, orthopedic, reconstructive, cosmetic, or thoracic surgery.

Companies sponsoring the research will receive a royalty-

free license to use patents resulting from the work. More importantly, Hughes said, they will have a competitive advantage in developing new collagen-based products that are more useful than those produced on Earth. Technology gained from this research should be transferable to other product areas as well.

SATELLITE BUSINESS SYSTEMS

A Delta rocket lifted off from the Cape Canaveral Air Force Station at 5.49 a.m. EST on 15 November, carrying aloft the SBS-A satellite. The SBS-A is owned by Satellite Business Systems and is designed to beam information, pictures and words to a network of Earth stations throughout the United States. The highest powered communications satellite ever launched, SBS-1, will join eight other American satellites currently in orbit that are providing both radio and television transmissions, in addition to business communications.

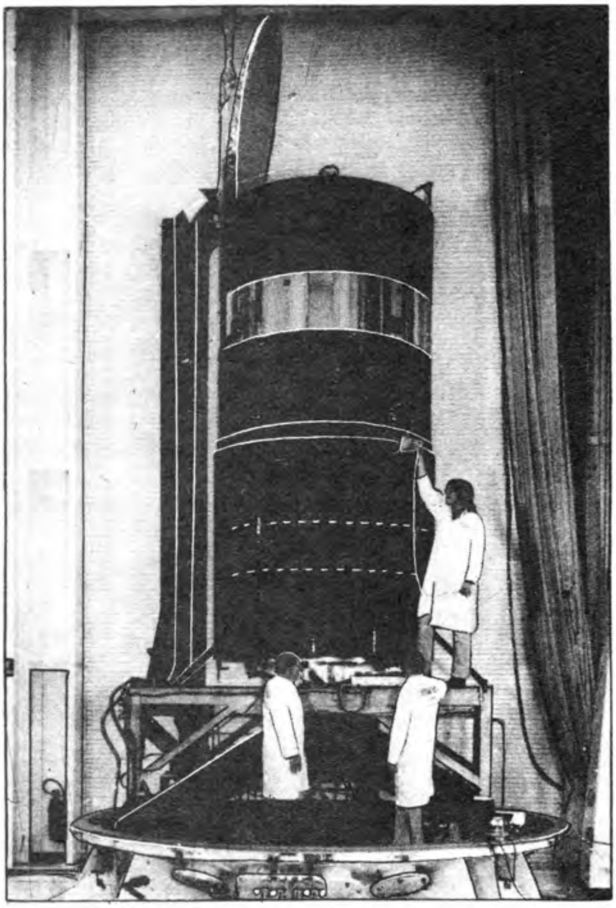
The launch was a double success for NASA and McDonnell Douglas Astronautics Co. The standard Delta rocket was topped with a new upper stage that can fly on either a Delta or Space Shuttle. The new upper stage allows the launch of about a 20 per cent heavier payload.

Satellite Business Systems is the partnership formed in December 1975 by IBM Aetna Life and Casualty, and Communications Satellite Corporation, to provide large corporations with high-speed communication networks, between their farflung facilities. The company has also announced plans to offer low-cost, long-distance phone services.

By 17 November the satellite was in a circular orbit at roughly 22,300 miles above the equator in an area a little south of El Paso, Texas.

The satellite, built by Hughes Aircraft Company, is something of a jack-in-the-box. When launched, it is 111 in. long, but as it went into its final orbit a drum of solar panels telescoped out and an antenna popped up like the lid of a kitchen garbage can, making the satellite 260 in. long.

The satellite operates at frequencies two to three times higher than those being used by earlier communication satellites. Consequently, customers will be able to use a relatively small antenna — capable of being mounted on the roof of a building — to transmit the equivalent of 10 million words a second.



FIRST OF A KIND. The new SBS communications satellite, launched on 15 November 1980, is pictured during pre-flight tests at Hughes Aircraft Company, El Segundo, California. The first of a series of three, the spacecraft was built for Satellite Business Systems to provide secure voice, video, data and facsimile services to U.S. businesses.
Hughes Aircraft Company

ARIANE: THIRD FLIGHT TEST

The launching of the Ariane O3 space rocket carrying the geostationary satellites APPLE and Meteosat 2 has been put off until probably June 1981 to allow more time for analysis of the engine problem which destroyed the O2 vehicle last May.

The following communiqué was issued jointly by ESA and CNES:

1. The Ariane programme comprises four flight tests. The first was a complete success. The second was a failure due to the malfunctioning of a 1st-stage engine. The studies and ground tests made on this type of engine since May 23 have revealed the causes of the malfunction. Two high frequency vibration phenomena, to which satellite launcher engines are sensitive and whose elimination is a normal part of the development process during ground and flight tests, have been identified. One of them, located in the 2300 Hz band, can be regarded as already rectified; the other, at 2700 Hz is the subject of thorough investigation and action which still need some time to complete.
2. In these circumstances, and in view of the time required to ship the launcher to Kourou and prepare it on the launch site, the third flight test will very probably take place in June 1981. The fourth and last flight test will subsequently take place in autumn 1981.
   This timetable remains compatible with the commitments entered into to place in orbit scientific and telecommunications satellites in late 1981 and in 1982.
3. This additional programme of studies and tests remains within the overall financial envelope fixed at the start of the programme, which comprises a 20% margin for contingencies.

SUPERMETAL

Question: What metal is lighter, stronger and stiffer than aluminium and carries a lifetime guarantee in space?
Answer: Supermetal! Aluminium or magnesium laced with thousands of hair-thin strands of graphite fibres. Technically named, "metal-matrix composites."

Sandwiched between aluminium or magnesium, the featherlight graphite makes the finished materials stronger, about four times more rigid and up to 35 per cent lighter.

Unlike other metals in space, the composite also provides thermal stability — remaining unaffected by heat or cold — since graphite-metal matrix composites will neither expand nor contract significantly.

Because they resist solar radiation and do not "out gas," they

are almost indestructible and should function in space indefinitely, said Glenn M. Ecord, senior metals engineer of the Johnson Space Center.

The new supermetals are being developed for space operations of the future. They will be used for large, permanent space structures, antennae, geodetic beams, solar arrays, booms and masts, large mirrors and their supports, and deployable space antennae.

Supermetal composites also promise to benefit construction, the automobile industry and commercial aircraft with lighter and stronger structures.

Although the metal-matrix composite is about 15 years old, aerospace metal specialists about four years ago learned how to produce a high quality material using a special coating to bond the graphite fibres to metal.

First such test hardware was delivered by Lockheed to the Johnson Space Center late last year. Lockheed provided two wave guides — box-like devices designed to direct microwaves for solar power satellites of the future.

ELECTIONS TO COUNCIL

The Report of the Scrutineers on the ballot papers counted up to and including 31 January 1981 was as follows:

The Report of the Scrutineers on the ballot papers counted up to and including 31 January 1981 was as follows:

Number of Papers received	930
The number of spoilt Papers was	1

The names of the candidates and the number of votes cast for each was as follows:

Position	Name	Number of Votes
1.	A.T. Lawton	873
2.	R.C. Parkinson	857
3.	G.J.N. Smith	828
4.	C.R. Turner	688
5.	I.G. MacKinlay	176
6.	F.R. Smith	133

The four Candidates receiving the highest number of votes and who were accordingly declared elected were:

A.T. Lawton	R.C. Parkinson
G.J.N. Smith	C.R. Turner

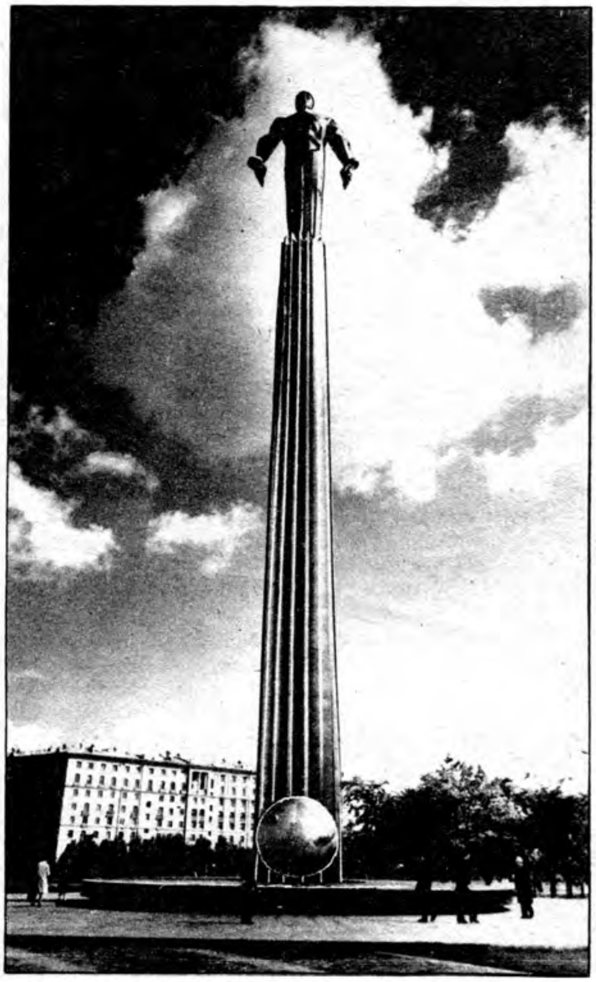
OUR NEW SPACE LIBRARY

We are seeking many technical books and similar items on astronomy, space research and space technology, and would welcome hearing from members with material they would like to donate to us to help fill the gaps.

Please write to the Executive Secretary first of all, indicating what you would like to present to us.

The library will be open to members from 5.30 - 7.30 p.m. on each of the following dates

26 March 1981	8 April 1981
29 April 1981	6 May 1981
20 May 1981	



This month the astronautical community celebrates the 20th anniversary of the world's first space flight achieved by Yuri Gagarin on 12 April 1961. Photo shows the imposing new monument to the pioneer cosmonaut which has been erected in Moscow. At the foot of the monument is a full-size replica of the spherical re-entry vehicle in which Gagarin made a single orbit of the Earth.

Photograph by Nikolai Malyshev TASS

Open to members of the Society both in the UK and USA

SOLAR ECLIPSE JULY 12 - AUG. 2, 1981

The Southern California Branch is organising a group expedition to view the solar eclipse on 31 July 1981. The tour will include visits to many astronomical, archeological and historical sites, leaving by air from London to Peking and travelling by rail through Ulan Bator and Irkutsk to Bratsk, where the group will view the eclipse. Return will be through Moscow.

Arrangements will be in the hands of Mr. R.V. Frampton, Mail Stop 264-519 Jet Propulsion Laboratory, Pasadena, California 91103, USA.

Members interested should contact Mr. Frampton for further details.

Total cost from London will be about £1,560 ($3,595)

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

SOCIETY NEWS

E.S. Mallett Moves to ESA

Mr. E.S. Mallett (Fellow) has been appointed Director of Application Satellite Programmes at the European Space Agency. Following a long career in the field of instrumentation for target aircraft and guided weapons at the Royal Aircraft Establishment, Mr. Mallett brings a wide range of experience to his new role. His recent appointments have included:

1976-78. Deputy Chief Scientific Officer, Department of Industry; Director Space: responsible for UK civil sapce applications, UK delegate to European Space Agency, Chairman of Communications Board.

1978-79. Under Secretary: Department of Industry;
Head of Research and Technology Requirements and Space Division; Responsible for civil research support for air, space, computers, electronics, mechanical engineering and ship and marine technology.

1979-80. Under Secretary; Department of Industry;
Director of the National Maritime Institute; leading 300 people doing research in fields of ship and marine technology and hydrodynamics involving large facilities for model testing.

E.S. Mallet (BIS Fellow), Director of Applications Satellite Programme, E.S.A.
National Maritime Institute, Crown Copyright

Historian at Johnson

Edward C. Ezell (Fellow) has assumed the position of historian at the Johnson Space Center. With his wife, Dr. Ezell has written two narrative histories under contract for NASA. *The Partnership: A History of the Apollo-Soyuz Test Project* (1978), and *On Mars: NASA's Explorations of the Red Planet, 1958-1978* (being prepared for publication at NASA Headquarters). The Ezells worked out of the JSC history office during the Apollo-Soyuz project and moved to the Washington, D.C., area in 1977 to complete their history of Viking at NASA Headquarters.

Born in Indianapolis in 1939, Ezell graduated from Butler University, Indianapolis (A.B., history), and the University of Delaware (M.A., history), where he was a Hagley Fellow. He received his Ph.D. in the history of technology from Case Institute of Technology, Cleveland, in 1969, after which he spent several years teaching at North Carolina State University and Sangamon State University, Springfield, Illinois. Since becoming interested in the space programme, Ezell has written several historical articles and papers on the subject. In 1978-1979, he served as an advisor for an international exhibition of space hardware in Tokyo.

Dr. Ezell, who replaces James M. Grimwood, recently retired, hopes to continue the history office's tradition of maintaining a working historical archives. Besides preparing a history of Apollo lunar explorations, Ezell is also eager to preserve the history of ongoing Johnson Space Center projects.

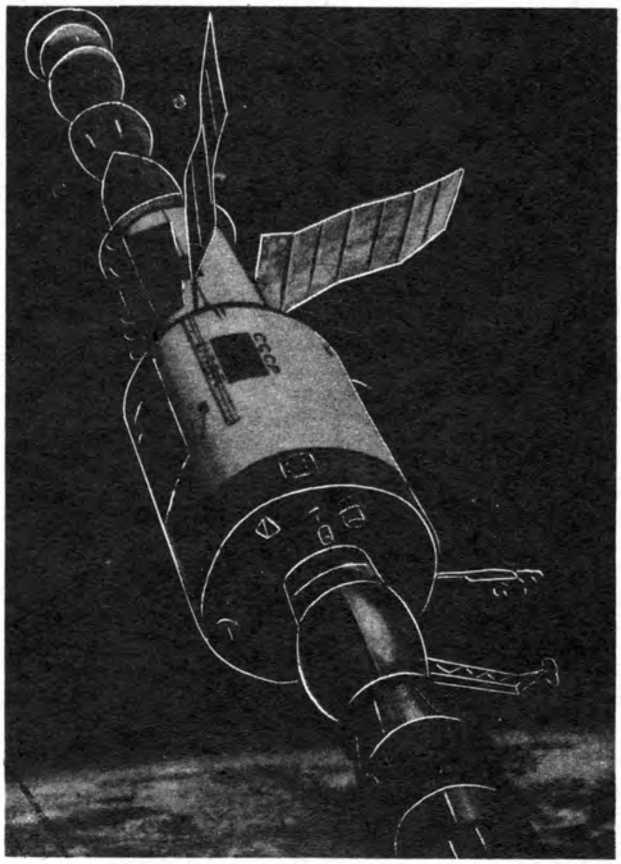
Award for BIS Artist-Member

We were delighted to hear that the British Association for the Advancement of Science had awarded a BIS member, Mr. Glenn L. R. Johnson, one of the ESA-sponsored prizes in the "ESA Young Europeans Access to Spacelab Man and Space Art Competition" (*Spaceflight*, Vol 22, p. 207).

Mr. Johnson's entry was a 420mm × 302mm size painting of the Soyuz 26/Salyut 6/Progress 1 complex orbiting the Earth above the Mediterranean Sea with the circumpolar stars region in the background.

Part of the prize was a 5 day trip to Paris from 28 November to 2nd December which included a day at the exhibition where the winning artworks were displayed; a boat-trip on the Seine at night, and excursions to various places of interest including the Eiffel Tower, Notre Dame and the Louvre. The party also toured the "Ariane" integration facility of Aerospatiale at les Mureaux where they saw the assembled first stages of Ariane LO3 and LO4, the next two launch vehicles.

On the final night each winner was presented with a bronze ESA commemorative model struck especially for the occasion.



The Soviet space station complex Soyuz 26/Salyut 6/Progress 1 - the painting entered for the ESA Man and Space Art Competition by Glenn L.R. Johnson. *Copyright Glenn L.R. Johnson*

BIS in the News

Our Society has continued to receive extensive news coverage and to benefit – both directly and indirectly – from publicity in the media both at home and abroad.

Top of the Pops with an unusual item was the article by Nick Kelly in the *Liverpool Software Gazette* of May 1980 entitled "Star Gate, a 3-d Planetarium." Not only did this manipulate the co-ordinates of 101 nearby stars, but ended up with a very nice advertisment for the Society, including its address.

Farther afield, *Electronics Today International* ran a "Project Daedalus" article in their November 1980 issue while, not to be outdone, David Hardy plugged the Society (and its address) in a letter to *Future Life* for August 1980, following mention in their March 1980 issue of the Daedalus Project.

At two different ends of the spectrum was a reference to "High Road to the Moon" published by the Society, again quoting our address, which appeared in *Scale Models* for September 1980 under the imprint of an article by Mat Irvine on "Spacecraft Kit Releases." Mat was even more to the fore in a short programme on "Spacecraft Models" which appeared on BBC TV on 28 August. Not only was he introduced as "A Member of the BIS" but he also managed to include in his programme both a demonstration and description, with further credits to the Society, of Project Daedalus.

The Society also gained a mention in several radio programmes arising from the 17th European Space Symposium. One was during an interview with David Ashford, one of the Speakers, the other a mention by the indefatigable Reg Turnill.

At the top end of the market, so to speak, was a full page advertisment for a new car, the Talbot Solari GL which appeared in the *Autocar* for 21 June 1980. Copies were sent to HQ by a number of members, for the advertisment showed a magnificent new vehicle parked immediately in front of the Society's office, which was used to provide an attractive background. The answer to the accompanying enquiries was: "No, the Secretary had not got a new car out of it!"

Not everything went so swimmingly. *The Christian Science Monitor* for 24 March 1980 managed to run a whole page on interstellar flight, without once mentioning Project Daedalus, the Society, or the many contributions appearing in the Red-Cover issues of *JBIS*, which have now passed the 25 issues mark and thus make it the most prolific Journal publishing material on this subject.

Also among the "Also-rans" were the reputed articles on the Society scheduled to appear in the *Sunday Telegraph* and the *Daily Mail**. Both absorbed a considerable amount of time by Members of the Council and Society Officers and illustrate the extent to which great effort is sometimes brought to nought.

However, we lifted an item headed "British Interplanetary Society invites Membership" – complete with our address – from the *Costa Blanca News* for 20 June 1980 it had been contributed by a new member, to an English language newspaper circulating among emigre Britishers in Spain.

Many enquiries stemmed from an article by Fred Pohl in an SF magazine, *Destinies* and high praise from the December 1980 issue of *Omni*, which mentioned that *Spaceflight* provided a comprehensive coverage of Western and Soviet space efforts. More bread-and-butter support came from Bob Forward who advertised our *JBIS* Interstellar Travel Bibliography, together with scaled-down membership application forms, to about 500 people interested in this topic. Similarly, T. K. Gibbons sent out 300 Membership forms with his SF catalogue to his customers. In similar vein 20 Membership packets were distributed by Bob Bramscher to an interested group. This last is an area of very great interest to the Society and often takes the form of Society support in the way of materials for university space-related courses.

Bookwise, *Spacecraft in Fact & Fiction* by Harry Harrison and Malcom Edwards included several references to the Society, including a reproduction of the *JBIS* front cover showing the old BIS spaceship design and two Ralph Smith drawings. An advertisment for *Spaceflight*, complete with a picture of its front cover, appeared in *The Next Whole Earth Catalogue* (over a million copies sold) though, unfortunately, the old rate annual dues were quoted.

Society support was given to the very successful "Man and the Stars" exhibition at Stoke-on-Trent which ran from 4 October-29 November 1980. This took the form of magazines, display material and films, together with a small supply of saleable material arranged with help from Michael Pace:

Last, but not least, was the Society's presence at the *Eagle Convention*, actually its 30th Anniversary, held in London in April 1980. Several members rendered Trojan assistance to put on a very good display which featured the Society very well indeed.

To all those who helped in our membership drive we extend our most grateful thanks

Obituary

WALTER R. DORNBERGER

Dr. Walter R. Dornberger died at the age of 94 during the early days of July, 1980 during a visit to his motherland of the Federal Republic of Germany. Dornberger had been residing in Apado, Mexico.

Ironically, his death came only weeks before the 30th anniversary of the Bumper 8 launch from Cape Canaveral on 24 July, 1950. The rocket was a German V-2 captured during World War II, topped with a U.S. Army WAC-Coporal as second stage.

Dornberger was born in Giessen, Germany on 6 September, 1885. He grew up in a home filled with music, gay spirits and rich food. With his brothers he romped and played in the sprawling gardens. When Walter was ten, his father gave him a gun so that they might hunt together.

Dornberger reminisced about his life for a publication of Bell Aerospace: "Custom even decided what my career was to be. In German families, the eldest son inherits the family business, the second son goes into the Army, and the third son is free to do as he pleases. I was the second son. So, though I wanted to become an architect [the First World War intervened and] I volunteered in the German Army in August, 1914. By November of that year, my world of carefree happiness tumbled — the War marked the end."

On 27 October, 1918, Lt. Dornberger was captured by the Second American Marine Division and turned over to the French. He spent the next two years as a prisoner of war in Uzes, in southern France.

He resumed his military service upon his return from France and eventually took up duties as assistant to Captain von Horstig of the Ballistics Branch of the Army Weapons Department.

Dornberger was on his own, tackling one of the biggest tasks ever assigned to a young officer — that of spearheading a revolution in weaponry. The magnitude to which this effort would grow could never have been imagined by Dornberger in

1930 as he settled behind his desk and started digesting the collection of reports.

The Army Weapons Department had contacted individual inventors, particularly those concerned with rockets, and had financially supported their efforts, hoping to gather reliable data regarding specific impulse, fuel consumption and other fundamentals.

"One small outfit in Berlin promised that within two years it could send up a man in a liquid rocket to an altitude of some miles", Dornberger recalled. "Though the promise was not backed up by anything, they wangled 50,000 marks for it! This kind of practice really angered me".

Dornberger proposed in 1931 that a test facility be established at Kummersdorf. At this experimental station, he could then determine the definite merits of the individual rockets and engines.

Dornberger recalled, "At that time, we had in Germany approximately five groups which were busy with the development of liquid rockets and engines of liquid rockets. The first one was the VfR, the German Society for Interplanetary Travel, with a membership of about 900; experiments were carried out at a munitions dump in the northern part of Berlin which they called Raketenflugplatz (rocket airfield). A youthful Wernher von Braun was a member but the President was Professor Hermann Oberth, who had been honoured in 1930 with the first Annual Award for Astronautics, he REP-Hirsch Prize. (This serious gesture, which greatly dignified the field, was instituted by two outstanding Frenchmen: Robert Esnault-Peltrie, inventor of the joy-stick, and Andre Louis-Hirsch, prominent banker with an abiding interest in the furtherance of spaceflight).

"Another of the experimental rocket groups was headed by an inventor, Johannes Winkler, who worked in his own workshop and built some small rockets which exploded every time he ignited them. The next group was that of Fredrich Wilhelm Sander in Wesermünde; this group not only developed solid rockets — black powder rockets — but worked on nitric acid and kerosene fuel too, with some success".

Dornberger continued: "The Heylandt Company Association for the Utilization of Industrial Gases worked in conjunction with Max Valier, for whom they had developed liquid fuel rocket motors for a racing car. While Valier was testing a motor during May, 1930, there was an explosion in the courtyard of the factory and a piercing splinter caused his death. As a result of the accident, Heylandt ceased work with liquid rocket engines: it was a real loss because the work done at the factory was outstanding and we had given them a contract for the development of an engine to give us information about different propellants. Two very good men who had worked for the company until that time and who later went to work for me were Walter Riedel and Arthur Rudolph . . . ."

The night of 21 December, 1932 was bitterly cold at the Experimental Station West, 17 miles south of Berlin. As Dornberger awaited the initial test firing of the first liquid engine developed under von Braun's Kummersdorf group, he was sheltered by a slender pine tree. The recently completed test stand, measuring 18 ft by 12 ft, stood like a symbol of progress. Proudly he related: "The place was full of switches, little valve handwheels, reducing valves, three-way cocks, electrical instruments, clocks, rows of meters and other gadgets connected with the fuel tanks and critical points of the combustion chamber that needed careful watching . . .

"At the main door of the test stand, von Braun, very cold, was stamping his feet. He was holding a rod 12 ft long with a can of gaseline fastened to the end. Riedel called out from behind the wall that pressure was now correct, and von Braun lit his gigantic match and held the flame under the exhaust nozzle . . . There was a swoosh, a hiss, and — crash! . . . Cables were on fire in a hundred places. Thick, black, stinging fumes of burning rubber filled the air. Von Braun and I stared at each other wide-eyed. We were uninjured. The test stand had been wrecked."

Longer, harder, more carefully they worked, directing their attention towards the assembly of components into a completed rocket. When the A-1 was found to be too nose-heavy, the A-2 was born. Its gyroscope was moved from the nose to the middle of the missile. Early in December, 1934, two A-2's were ready for testing. Gracefully they rose 1.4 miles into the skies above Borkum Island in the North Sea. After that came A-5, Peenemunde — and the V-2.

In February, 1945, Dornberger moved his staff to the southern slope of the Harz Mountains. Dornberger spent the last month before surrender in an Alpine resort with von Braun and his staff. As part of the U.S. Army's Operation Paperclip, 127 of the top scientists were brought to the United States.

Twice during his lifetime, the leader of his country had taken him upon the path to war. Twice, his world had collapsed. Realistically, he knew that the strides his group had achieved in rocketry, could only have been accomplished under a wartime economy; despite its turmoil and setbacks, it had produced the first practical vehicle for space. The door to the future was well ajar.

After working at Bell for several years Dornberger expressed his pleasure with the association and explained, "Human beings tend to be conservative . . . they like to crawl ahead, a little at a time. Even with many scientists — they are afraid of risking a real leap into the future. Here at Bell we can leap".

One of the first leaps was his proposal for a rocket powered research aircraft. "For speeds in between the X-2 and the BOMI — a bomber-missile project I had — I wanted an experimental airplane with a Mach number of 7. I did some calculations, proposed the whole thing to our chief engineer — at that time, Bob Woods — and he took the idea to the National Advisory Committee on Aeronautics. After about a year, it became a live project, known as the X-15".

Dornberger described the Space Age as holding dramatic prospects. "Space is nothing we should be afraid of. Space is only an extension of the field of operation for mankind: it is a new dimension that is given man for his use. This is a point I would like to stress: I believe in the utilization, not the exploitation of space. We must not be tempted into space stunts".

Dornberger will be remembered as a man who turned a military assignment into a project which led to the threshold of space.

GERALD L. BORROWMAN

NOTES ON SOVIET LAUNCH VEHICLE DESIGNATIONS

By Mark Wade

Introduction

In the absence of any system of launch vehicle designations revealed by the Soviet Union, Western observers have invented their own to keep track of the various Russian space boosters. The most generally used is that devised by Dr. Charles Sheldon II of the US Library of Congress (henceforth "LoC"). At the same time, a few of the designations utilised by the US intelligence agencies have been revealed ("DoD" designations).

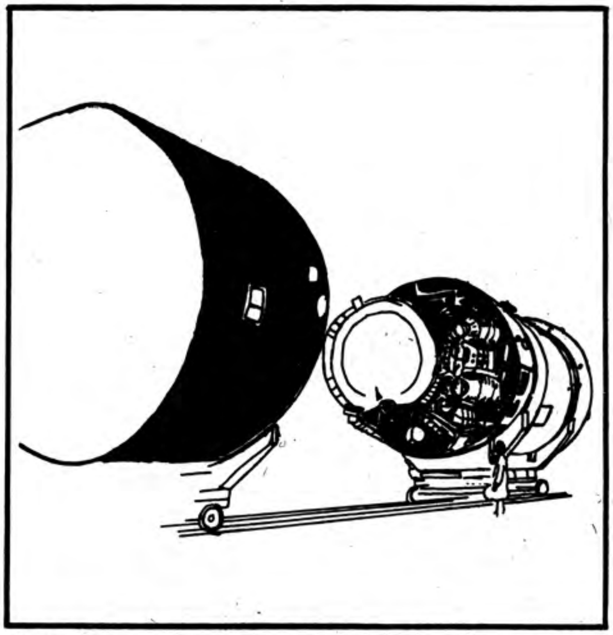
While the LoC system is descriptive, a particular designation revealing the stage composition of a vehicle, the DoD system is sequential, a designation revealing the order in which vehicles appeared. Thus, the SL-9, SL-12, and SL-13 are all variants of the Proton (LoC "D") booster, being the 2, 4, and 3 stage versions.

The DoD scheme is peculiarly suited to the requirements of photographic reconnaissance. A vehicle may be initially referred to by its launch complex designation. For example, the Sheldon "G" vehicle ("Webb's Giant") was initially referred to by the DoD as the "J" vehicle, "J" indicating the ninth launch pad complex to be erected at Tyuratam. Once the vehicle itself is photographed, it receives a new designation. Thus the G vehicle became the "TT-5", the fifth booster to be detected at Tyuratam. Finally, upon launch, the vehicle is given an "SL" designation. The TT-5, not having been successfully launched, has evidently never received such a designation.

It is possible, based on available information, to make a correlation between the LoC and DoD systems. We may additionally list Soviet revelations concerning rocket motor designations. The results of such correlation are given in Table 1.

Note that there is one more DoD than LoC designation in the period between SL-5 and SL-9. We have accommodated this discrepancy by considering the triple launch of 18 August 1964 to have been boosted by a combination of the SS-5 Skean with the Sandal RD-119 second stage. Sheldon considers this to be the first launch of the C vehicle; we have moved that up to the first quintuple launch on 16 July 1965. Other candidates for booster variants not noted by Sheldon in this period are Elektron (10 July 1964; A-1 with small separation motors) and Kosmos dual launches from Kasputin Yar (22 August 1964; SL-5 with third stage?).

Note that Russian rocket motors utilising cryogenic liquids are given numbers in the "RD-100" series, while those burning storable propellants receive designations in the "RD-200" series.



SL-12, D-1e, escape stage, seen here with its Luna 17 payload. This large escape stage has been used to launch the heavier generation Luna, Venera, Mars, Zond, and the new geostationary orbit communications satellites. It is the fourth stage of the D-1e launch vehicle. *Copyright Charles P. Vick*

Table 1. Designations for Soviet Launch Vehicles.

First Launch		Designation		Lower Stage		Russian Engine Designation				Typical Mission
		DoD	LoC	DoD	NATO	Stage 1	Stage 2	Stage 3	Stage 4	
4 Oct	1957	SL-1*	A	SS-6	Sapwood	RD-107	RD-108	none	none	Sputniks 1, 2, & 3
2 Jan	1959	SL-2*	A1	SS-6	Sapwood	RD-107	RD-108	Kosberg 5t	none	Lunas 1-3, Vostok
4 Feb	1961	SL-3*	A2e	SS-6	Sapwood	RD-107	RD-108	Kosberg 30t	?	Early planetary, Molniya
4 Feb	1961	SL-4	A2	SS-6	Sapwood	RD-107	RD-108	Kosberg 30t	none	Soyuz, reconnsats
16 Mar	1962	SL-5*	B1	SS-4	Sandal	RD-214	RD-119	none	none	small & double Kosmos
1 Nov	1963	SL-6**	Am	SS-6	Sapwood	RD-107	RD-108	Polyot	none	Polyot
18 Aug	1964	SL-7**	none	SS-5?	Skean?	RD-216?	RD-119?	none	none	Triple Kosmos?
16 Jul	1965	SL-8	C1	SS-5	Skean	RD-214	RD-2XX	none	none	Quintuple Kosmos, others
16 Jul	1965	SL-9	D	N/A	N/A	RD-253	RD-254?	none	none	Protons 1 & 2
27 Dec	1965	SL-10**	Alm	SS-6	Sapwood	RD-107	RD-108	?	none	Kosmos 102, 125
17 Sep	1966	SL-11**	Flr	SS-9	Scarp	RD-2XX	RD-2XX	?	none	FOBS
2 Mar	1968	SL-12	D1e	N/A	N/A	RD-253	RD-254?	RD-2XX	?	Late planetary, syncomsat
2 Mar	1968	SL-13	D1	N/A	N/A	RD-253	RD-254?	RD-2XX	none	Proton 4, Salyut
19 Oct	1968	SL-14**	Flm	SS-9	Scarp	RD-2XX	RD-2XX	?	none	Military Kosmos
2 Dec	1970	SL-15**	D1m	N/A	N/A	RD-253	RD-254?	RD-2XX	?	Kosmos 382

* high confidence correlation ** low confidence correlation N/A D vehicle not based on missile.

Because of limitations on space, we have been forced to hold over Neville Kidger's "Salyut 6 Mission Report" to a future issue. Ed.

THE BRITISH INTERPLANETARY SOCIETY
LIMITED *(by guarantee)*

27/29 South Lambeth Road, London SW8 1SZ

NOTICES OF MEETINGS

Lecture
Title: **ASPECTS OF ROCKET PROPULSION**
by M. R. Fry
Venue is the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **26 March 1981,** 7–9 p.m.

Admission by ticket, available from the Executive Secretary, enclosing a reply-paid envelope.

Lecture
Title: **THE INFRARED ASTRONOMICAL SATELLITE (IRAS)**
by Dr. R. Holdaway
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **8 April 1981,** 7–9 p.m.

Admission by ticket, available from the Executive Secretary enclosing a reply-paid envelope.

Symposium
Theme: **SPACE TRANSPORTATION SYSTEMS FOR THE 1990's — Requirements and Solutions**
Offers of Papers are invited for presentation at a one-day meeting to be held in the Golovine Conference Room, Society HQ, 27/29 South Lambeth Road, London, SW8 1SZ on **15 April 1981,** 9.30 a.m. to 4.30 p.m.

Registration forms and copies of the Final Programme will be available from the Executive Secretary in due course. Please enclose a reply-paid envelope with request.

Lecture
Title: **THE PHILATELY OF THE SOVIET SPACE PROGRAMME**
by Rex D. Hall
Venue is the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **29 April 1981,** 7–9 p.m.

Admission by ticket only. Apply to the Executive Secretary, enclosing a reply-paid envelope.

One-Day Discussion Meeting
DAEDALUS IN RETROSPECT
A one-day discussion meeting on Project Daedalus, three years after completion of the study, to be held in the Golovine Conference Room, at the Society's HQ Building, 27/29 South Lambeth Road, London SW8 1SZ on **6 May 1981,** 9.30 a.m.–4.30 p.m.
The Daedalus concept will be reviewed in the light of work appearing since the study, and various areas of investigation stimulated by the Project will be discussed. Offers of short contributions to the discussion should be made to Dr. A. R. Martin, c/o British Interplanetary Society, at the above address.
Members wishing to attend should apply in good time to the Executive Secretary, enclosing a reply-paid envelope.

Film Show
Theme: **THE MAKING OF AN ASTRONAUT**
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **20 May 1981,** 7–9 p.m.

Admission by ticket only, available from the Executive Secretary, enclosing a reply-paid envelope.

Lecture
Title: **PLANET 10 - THE GIFT FROM GALILEO**
by A.T. Lawton

The Theme is based on a very recent discovery that Galield saw and recorded the planet Neptune in 1612.

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **27 May 1981,** 7-9 p.m.

Admission is by ticket only, available from the Executive Secretary, enclosing a reply-paid envelope.

Technical Forum

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 on Friday **29 May 1981,** 6.30-9.00 p.m. and Saturday **30 May 1981,** 10-12 noon and 1.30-3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet Space Programme are invited to attend. A registration fee of £1.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

New JBIS Series
SPACE CHRONICLE

In August 1980 and January 1981 the Society published the first two issues of JBIS Entitled *Space Chronicle.* The *Chronicle* is intended for papers at a more general level than readers usually expect from the Journal. In effect, the *Chronicle* is a new space magazine and the next issue - May 1981 - will carry 48 pages on a wide variety of topics.

Nick Johnson will be familiar to *Spaceflight* readers for his work on the Soviet space programme. Here he looks at the classification of Soviet photosurveillance satellites according to their orbital parameters. Vince Calouri of Boeing outlines the requirements for an Orbital Transfer Vehicle to give the basic Shuttle a geosynchronous orbit payload capability.

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SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

32nd INTERNATIONAL ASTRONAUTICAL CONGRESS

Rome, Italy, 6 to 12 September 1981

SPACE: MANKIND'S FOURTH ENVIRONMENT

Over the centuries mankind has been concerned, to different extents, with three environments: the geosphere (land), the hydrosphere (oceans) and the atmosphere (air). Technical developments and human achievements during the past decades have progressively emphasised that mankind must also be increasingly concerned with a FOURTH environment: SPACE.

As the IAF 32nd Congress is the last international gathering of space scientists and engineers before the UNISPACE 82 Congress organised by the United Nations in 1982 and falls on the 20th anniversary of the first manned space flight, it has been felt timely and appropriate to devote it to promoting awareness about the challenges and debating the problems posed by the use, further exploration and management of this fourth environment.

The scenario will be set by invited lecturers illustrating the CHALLENGES OF THE FOURTH ENVIRONMENT and by a guest speaker, the Secretary General of the UNISPACE 82 Congress.

The theme will then be developed through a series of symposia and technical sessions organised by the IAF and by the International Academy of Astronautics (IAA), dealing with:

1) the access to and the permanence in the fourth environment,
2) its exploitation and further exploration,
3) its management,
4) the development of the needed soft and hard technologies.

The overall structure of the Congress is shown below:

SPACE: THE FOURTH ENVIRONMENT

Thematic Development	Congress Activities: Name	Type
The Fourth ENVIRONMENT:		
• What it is	CHALLENGES OF THE 4TH ENVIRONMENT	Invited Lecture
• Reaching it	SPACE TRANSPORTATION SYSTEMS	Symposium A
• Staying there	SPACE STATIONS	Technical Sessions
• Exploiting it: the 4 Generations of Peaceful Space Utilization	TELECOMMUNICATIONS	Symposium B
	OBSERVATIONS OF THE OTHER 3 ENVIRONMENTS	Symposium C
	SCIENCE AND PROCESSES IN THE SPACE ENVIRONMENT	Symposium D
	ENERGY FOR AND FROM SPACE	Symposium E
• Exploring it	SPACE EXPLORATION	Symposium F
• Managing it	SPACE CIVILIZATION	
	— Space Economics and Benefits	Symposium G
	— IISL Colloquium on the Law of Outer Space	Symposium H
	— Influence of Space Development on the Humanities	Technical Session
	— Space and Mass Media	Technical Session
	— History of Astronautics	Technical Session
	— Communication with Extra-Terrestrial Intelligence (CETI)	Technical Session
	— Space and Education	Technical Sessions
	— 11th Student Conference	Technical Sessions
• Developing needed technology	SUPPORTING TECHNOLOGIES	Technical Sessions

A UNIQUE HISTORY OF YOUR SOCIETY

"HIGH ROAD TO THE MOON"

Every member of the Society ought to possess a copy of this unique new publication which records many of the Society's original ideas and discussions on Lunar exploration through the visionary drawings of the late R. A. Smith.

The pictures visualise the ideas on orbital rockets, space probes, ships to take men to the Moon and Lunar exploration itself. Some are familiar illustrations, others have never been published before.

Now, Dr. Bob Parkinson has brought these pictures together with a commentary which tells how the Society's pioneers imagined things would be and how they were. But the story goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

R. A. Smith, a former President of the Society, died in 1959. He had been one of the pioneers of the Society and left behind him a collection of nearly 150 paintings and drawings which recorded one of the most visionary periods in its history.

The book runs to 120 pages in large (A4) format and about 150 illustrations.

Price £6.00 ($16.00)

Members of the Society wishing to present papers are asked to notify Dr. L. R. Shepherd, Chairman of the BIS International Liaison Committee at Society H.Q. without delay. Papers intended for presentation at the Student Conference must be submitted via the Society.

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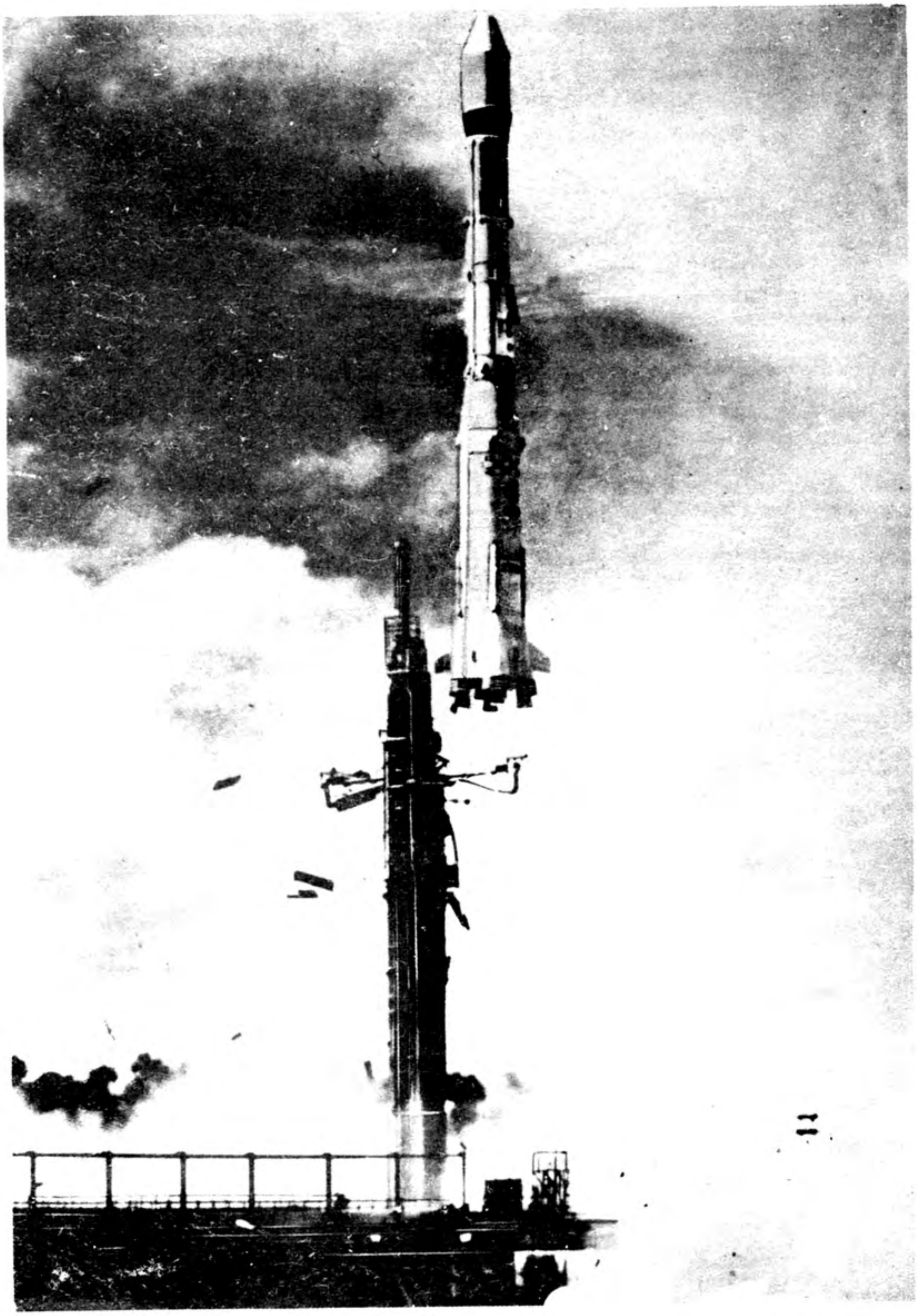

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VOLUME 23 No. 5
MAY 1981

THE BRITISH INTERPLANETARY SOCIETY
LIMITED (*by guarantee*)

BIS Development Appeal

OUR £75,000 TARGET

We thank most sincerely all those members and friends of the Society who have responded to that part of our Appeal which seeks to repay the final construction costs of our new Headquarters building.

We still have some way to go but your donations are helping to lighten the load. **With your help we have already raised the sum of**

£4,098

We now have to make that final effort to pay off the rest of the Loan. The importance of reaching our target at the earliest possible date cannot be emphasised too strongly.

We have already made enormous progress in creating a valuable property of style and elegance which at the same time, is wholly functional as administration offices. We hold regular meetings in our own Golovine Conference Room - and through great efforts we have now also made great strides in the foundation of our own Specialised Library of Space Science and Technology.

Practically all this has been done by voluntary contributions by people who support the ideal of International Astronautics - without Government help of any kind.
We are asking every member of the Society, at home and abroad, to make a donation to this urgent appeal to secure our hard-won resources against the tide of inflation.

Please send your donations, as soon as possible, to Mr. L.J. Carter, Executive Secretary, BRITISH INTERPLANETARY SOCIETY, 27-29 South Lambeth Road, London SW8 1SZ. They will be most warmly received.

We shall be reporting on progress in future issues. Ed.

THE SOCIETY'S LIBRARY: OUR NEED FOR BOOKS

Dear Member,

We are undertaking a substantial effort in endeavouring to build up a Specialised Space Library for the Society, though our efforts are greatly hampered by the fact that, in a period of rapidly-increasing inflation, the Society has no funds available for the purchase of books. This is why we need to rely solely on the goodwill of our members to help us acquire suitable material.

To support this Appeal, the Library Committee has asked me to write to each member of the Society who is known (or suspected) to be an Author of books of the right calibre on astronomy and space, to place our Appeal before them and seek their help, especially because the Committee particularly wishes to see that all relevant books published by members of the Society, even if they first appeared some years ago, appear on our shelves.

The Committee seek your support and hope that you will be willing and able to donate one or more copies of your works. Needless to say, if you have duplicates of any other material which you could consider parting with and donating to the Society, they would be extremely grateful for this too.

I hope you will be able to respond favourably.

L.J. CARTER
Executive Secretary

POSTAGE COSTS

In view of the recent heavy increase in the cost of postage we are asking all members communicating with the Society and its officials to enclose a reply-paid envelope.

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SPACEFLIGHT

A Publication of The British Interplanetary Society

VOLUME 23 No. 5 May 1981 *Published 15 April 1981*

Editor:
Kenneth W. Gatland, FRAS, FBIS

CONTENTS

COVER

THE LAUNCH OF ARIANE 03 has been scheduled at the Guyane Space Centre no earlier than June 1981. This follows a series of engine tests after injectors were modified in a bid to cure combustion instability problems which marred the flight of Ariane 02 in May 1980. The photograph shows the successful launch of Ariane 01 on 24 December 1979, resulting in a technological capsule and dummy payload of 1,600 kg being placed into a geostationary transfer orbit. The object of Ariane 03 is to launch a double payload: APPLE, an experimental communications satellite for India, and Meteosat 2, both to enter geo-stationary orbit. Ariane is built by some 50 European companies in 10 member states of the European Space Agency.

ESA

MILESTONES

February 1981

23 National Aeronautics and Space Administration informs European Space Agency that it may be forced to withdraw from International Solar Polar Mission (ISPM) because of budgetary constraints in the USA. Under the joint agreement, Europe and the United States each agreed to build a spacecraft, one to investigate the northern polar region of the Sun and the other to examine the southern polar region. Launch was to have been by Space Shuttle in 1985.

March 1981

1 West German private company, OTRAG, launches single-stage rocket built on the modular principle from Libya. The site is located near Seba Oasis, some 500 miles (800 km) south of Tripoli. Was fourth launching by the German company, three others having been made from Zaire. OTRAG are preparing to market a 4-module nitric acid/kerosene sounding rocket developing 12,000 kg thrust capable of lifting 100-400 kg payloads to 80-230 km altitude. A three-stage satellite launcher is being prepared for test in 1982-83.

2 British Aerospace and Plessey announce agreement to collaborate on defence communications satellites, the former supplying the spacecraft and the latter providing project support and ground terminals. BAe and Marconi are competing for the contract to develop the satellite which will replace Skynet IIB.

7 Martin Marietta at KSC begins 13-day programme to repair insulation of External Tank of Space Shuttle "Columbia" before maiden flight planned for the second or third week of April. Insulation became detached in two places during propellant loading trials in late January/early February. Work is being done on the launch pad using special work platforms.

12 Marconi Communications Systems announces contract worth nearly £5 million to convert British Telecom satellite Earth terminal, Goonhilly 4, for use as a Standard C terminal with Intelsat 5, the new generation of operational communications satellites. Goonhilly 4 was originally built by Marconi in 1978 as an experimental station to be used by British Telecom to provide the technology involved in operating in the 14/11 GHz frequency band, working with OTS.

12 Soviets launch Soyuz T-4 spacecraft from Tyuratam-Baikonur cosmodrome at 2200 hr (Moscow time) with Col. Vladimir Kovalyonok and flight engineer Viktor Savinykh (who becomes world's 100th space traveller). Launch celebrates Yury Gagarin's pioneer space flight one month before the 20th anniversary of that flight on 12 April 1961. Apart from 50 earlier Soviet cosmonauts, there have been 43 Americans and seven others - from Czechoslovakia, East Germany, Poland, Hungary, Bulgaria, Cuba and Vietnam. Other missions planned include a Mongolian and a Romanian.

13 Soyuz T-4 docks with Salyut 6/Progress 12 complex on forward airlock. Planned programme includes repair and maintenance, scientific experiments. *(Boris Belitsky, writing from Moscow, says Salyut 6 is "not quite the last of the series." Important results are being obtained particularly in surveying the Earth's natural resources. Space factory experiments carried out on board Salyut 6 are also yielding important results. Semiconductor devices of great interest to the electronics industry could result, leading to improvements in microwave and infra-red equipment. Furnaces aboard future space stations working at higher temperatures could lead to pilot-plant production of many promising new materials.* Ed).

14 An engineering-model pallet supplied by BAe Dynamics (Stevenage) will support a synthetic aperture radar (SAR) in the cargo bay of Space Shuttle "Columbia" during the second test flight. Experiment is part of NASA's Office of Space and Terrestrial Applications (OSTA) payload. The pallet, not originally designed to go into orbit, has been cleared for flight by BAe.

19 NASA announces with great regret that a technician has been killed at the Kennedy Space Center in a nitrogen filled compartment of the Space Shuttle "Columbia". Five others escaped asphyxiation.

20 Addressing 53-member nation UN Legal Sub-Committee on Outer Space, Mr. Sune Danieeson, Swedish delegate, urges early international negotiations on means to prevent an arms race in outer space.

21 **Soviet Weekly** reports that Russia is to conduct studies of the planets of the Solar System from a new observatory established 9,000 ft (2,740 m) up in the mountains of Kazakhstan. A 40in. (102 cm) telescope has already been installed. (Western sources believe the project is related to forthcoming attempts to send new-generation probes to investigate Venus and Mars and possibly the outer planets).

VOYAGER ENCOUNTERS SATURN

Voyager 1's flyby of Saturn, one of the most spectacular planetary encounters in space history, has produced a crop of scientific discoveries, observations and theories. Some of them are summarised here with acknowledgement to NASA and the Jet Propulsion Laboratory.

The Planet

The basic appearance of Saturn's atmosphere is similar to that of Jupiter, with alternating dark and light cloud markings. The features in the Saturnian atmosphere, however, are muted by the presence of a much thicker haze layer above the visible clouds. The belt/zone structure on Saturn also extends to much higher latitudes than on Jupiter.

Wind speeds in the atmosphere are not closely tied to the belt/zone boundaries as was apparently the case for Jupiter. The greatest wind speeds (more than 1,600 km or 1,000 m.p.h.) occur at the equator and are four to five times stronger than Jupiter wind speeds.

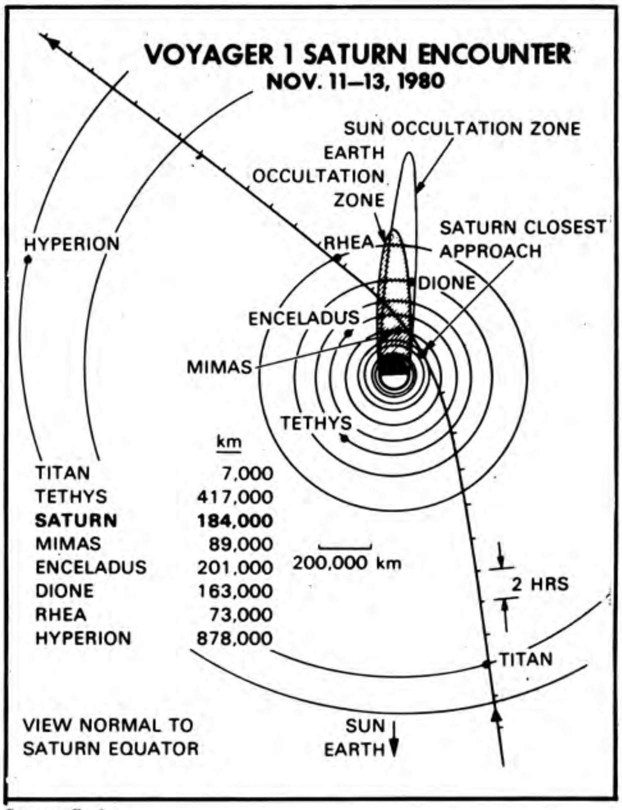
Temperatures near the cloud tops range from 86 degrees Kelvin (-305 degrees F) to 92 K (-294 F), with the coolest temperatures noted near the centre of the equatorial zone.

Auroral emissions were seen near the poles of Saturn; auroral-type emissions in the ultraviolet were also noted near the illuminated limbs of the planet.

The dark face of Saturn receives a substantial amount of light from the rings, especially in that hemisphere above the illuminated face of the rings.

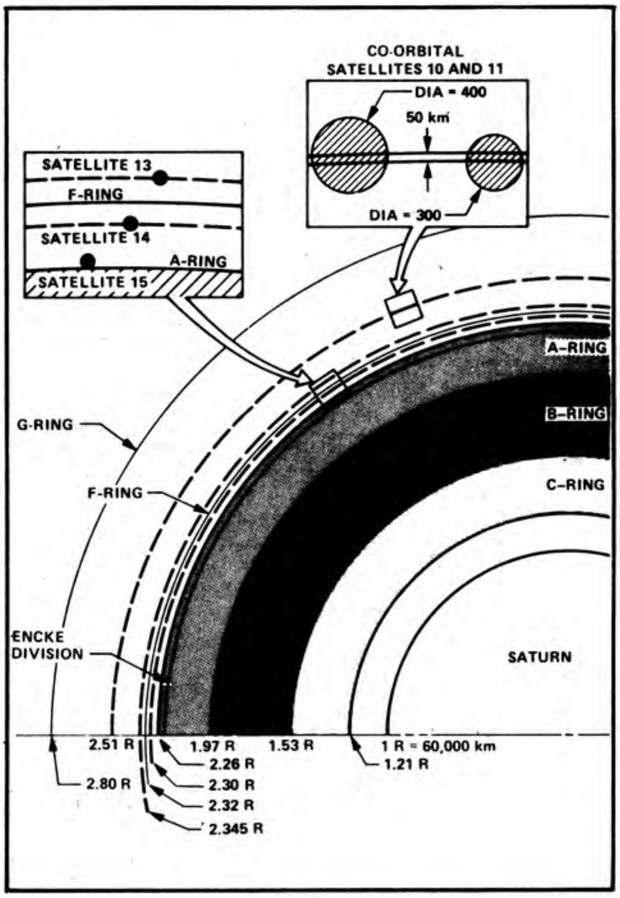
Lightning bolts have not been observed in the images of Saturn's dark face, but radio emissions typical of lightning discharges have been noted. These discharges are believed to emanate from Saturn's rings rather than from its atmosphere.

Radio emissions, primarily from the north polar region and near 90 degrees longitude, indicate that the body of Saturn and its magnetosphere rotate with a period of 10 hours 39 minutes 26 seconds.



Saturn fly-by.

Below, rings of Saturn showing the positions of the satellites 10, 11, 13, 14 and 15.



The Rings

The classically known A, B and C rings were observed by Voyager 1 to consist of hundreds of ringlets, a few of which are elliptical in shape.

The F ring, first discovered by Pioneer 11, is composed of three separate ringlets which appear to be intertwined. The inner and outer limits of the F ring seem to be controlled by two shepherding satellites, S-13 on the outside and S-14 on the inside. The outer edge of ring A is similarly shepherded by S-15. All three of these satellites were discovered by Voyager 1.

The existence of a D ring inside the C ring was confirmed by observations during Voyager 1's passage through the shadow of Saturn. The tenuous E ring, previously observed only from Earth during periods when Saturn's rings could be viewed edge-on, was also observed during shadow passage.

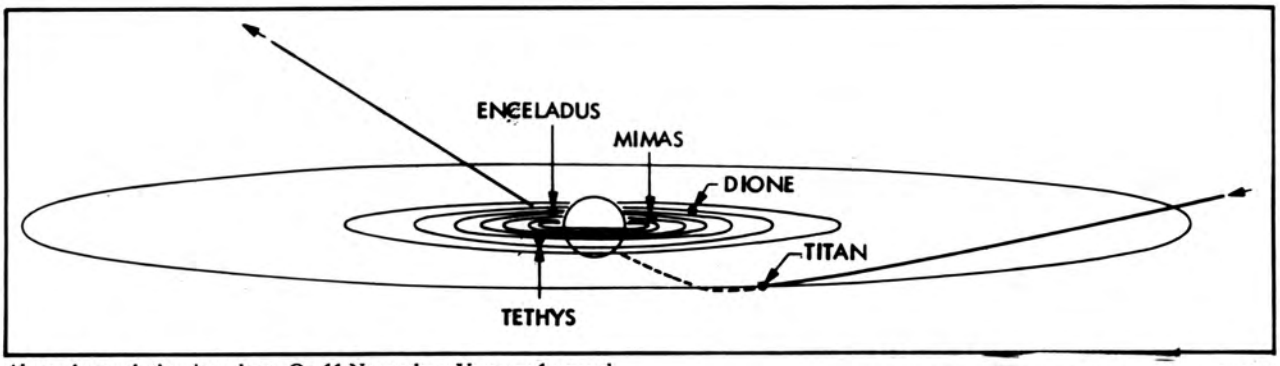
Measurements show that the D, E and F rings have a large population of particles less than 1/10,000 of an inch in diameter. Radio measurements of the C ring yield an effective particle size of about 1 metre (3 ft), but also suggest a wide distribution of particle sizes.

The existence of a thin ring just inside the co-orbital moons S-10 and S-11 was first inferred from the passage of its shadow across one of the moons, and later detected directly in the Voyager image of the E ring mentioned above.

The spokes in the B ring are dark in approach pictures and bright in forward-scattered light in post-closest approach pictures, and may be a result of electrostatic forces lifting fine particles above the face of the optically thick B ring. These spokes appear to corotate with Saturn's magnetic field.

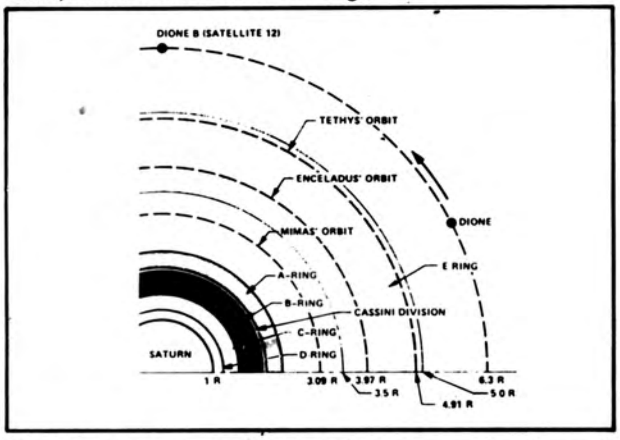
The New Moons: S-10, S-11, S-12, S-13, S-14, S-15

Each of the recently discovered moons of Saturn was photographed, but only S-10 and S-11 had large enough angular diameters in the images to determine their shapes.



Above, beneath the ring plane. On 11 November, Voyager 1 passed about 2,500 miles (4,330 km) from Titan's cloud tops and then dipped below the ring plane. About 22 hours later, on its outbound leg, Voyager 1 rose above the ring plane once again, passing through an area where Dione is thought to clear a path through the E-ring particles.

Below, moons of Saturn outside the rings.



Both are irregular in shape with their long axes pointed toward the centre of Saturn. S-11, the trailing satellite of this co-orbital pair is about 135 km (80 miles) long by 70 km (40 miles) wide. S-10 is somewhat larger with an average diameter of about 200 km (120 miles). Both bodies are apparently composed of water ice, and both orbit the planet at a distance of 91,000 km (57,000 miles) above the cloud tops of Saturn.

Little is known about S-12, S-13, S-14 and S-15 other than their orbits. S-12 (sometimes referred to as Dione B) orbits at the same distance from Saturn as Dione, slowly oscillating about a point 60 degrees ahead of Dione. As mentioned earlier, S-13, S-14 and S-15 were discovered by Voyager 1 and orbit just outside the F ring, just inside the F ring, and just outside the A ring, respectively.

Other satellites may be discovered as Voyager 1 scientists examine the voluminous data returned from the encounter, or from photos to be returned this summer by Voyager 2.

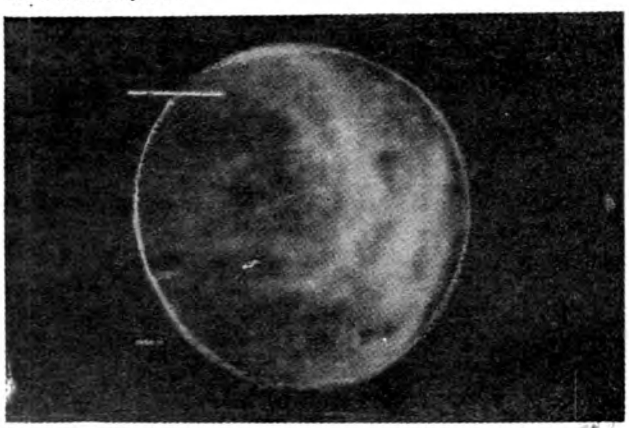
The Inner Moons: Mimas, Enceladus, Tethys, Dione, Rhea

Each of these five inner moons of Saturn is approximately spherical in shape. Their densities and surface brightness indicate that they are composed mainly of water ice. Tethys, in particular, seems to be almost pure ice, whereas Dione may range from 30 to 70 per cent rock.

All five of these moons represent a size of body not previously explored by space probes, intermediate in size between Phobos and Deimos (Mars' moons) and Amalthea (Jupiter), and the terrestrial-sized bodies - Mercury, Moon and the Galilean satellites of Jupiter. Their measured diameters, accurate to about 20 km (12 miles), are: Mimas, 390 km (240 miles); Enceladus, 500 km (310 miles); Tethys, 1,050 km (650 miles); Dione, 1,120 km (695 miles); and Rhea, 1,530 km (950 miles).

Above, this Voyager 1 image shows Saturn's limb in the lower left and the inner edge of the C-ring in the upper right corner. Cutting across the frame is the shadow of Saturn cast on the ring plane. Visible between the C-ring and the planet is the very faint D-ring.

Above, Dione from a range of 149,000 miles (240,000 km). Bright radiating patterns probably represent debris thrown out of impact craters. *Below,* Rhea from a range of 1,196,000 miles (1,925,000 km). The bright streaks may be pulverised ice grains thrown out by meteoroid impacts.



With the exception of Enceladus, all of these moons have heavily cratered surfaces, reminiscent of the Moon and Mercury. Mimas has one very prominent crater which has a diameter almost one fourth that of Mimas itself. Stretching for 750 Km (470 miles) across the surface of Tethys is a 60 km (40 miles) wide valley, which appears to be a fracture in the crust of the moon. Several sinuous valleys, some of which appear to branch, are visible on Dione's surface.

Both Dione and Rhea have brighter wispy streaks which stand out against an already high reflective surface. These are probably the result of relatively fresh ice ejecta thrown out of more recent (on a geologic time scale) impact craters.

Of these five inner moons, only Enceladus shows no evidence at a scale of 12 km (7 miles) of any impact craters.

Because the maximum intensity of the E ring occurs near the orbit of Enceladus, it is speculated that Enceladus may serve as a source for E ring particles. Enceladus was not a prime target for Voyager 1, but Voyager 2 will fly closer and return higher resolution images than Voyager 1.

This image of the moon Iapetus shows an unusual variation: the leading side is dark while the trailing side is five to six times brighter. More pictures of the moons of Saturn appeared in *Spaceflight*, March 1981, pages 69-70.

Titan

Titan, Saturn's largest moon and the only moon in our Solar System known to possess any substantial atmosphere, was thought to be the largest satellite in the Solar System. It is now known to be smaller than Ganymede, largest of Jupiter's Galilean satellites. Its precise diameter is not yet known, but is less than 5,120 km (3,180 miles), compared with Ganymede's 5,270 km (3,275 miles). This implies a density twice that of water ice for Titan, requiring it to be an equal amount of rock and ice, as is Ganymede.

The surface cannot be seen because it is hidden by a dense haze at least 280 km (175 miles) thick.

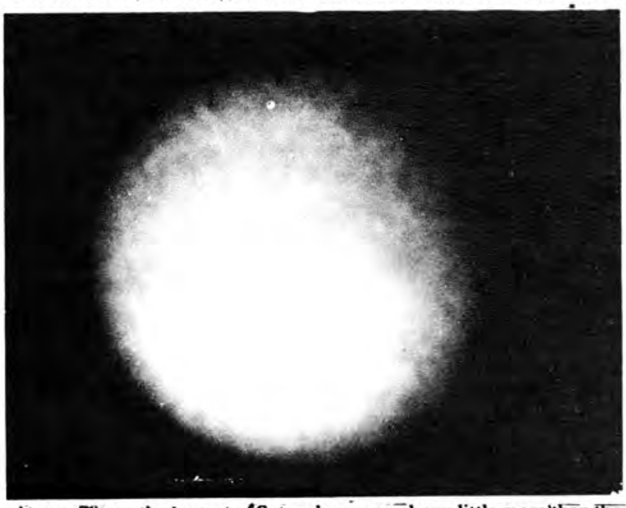
The atmospheric pressure near Titan's surface is 50 per cent greater than that of Earth.

The atmosphere of this unique moon contains methane, ethane, acetylene, ethylene and hydrogen cyanide but the bulk of the atmosphere is now believed to be composed of nitrogen, the main constituent of Earth's atmosphere.

Lakes of liquid nitrogen may exist near the poles of this strange world, the surface temperature of which is probably 90 K (-300 F), only slightly warmer than the boiling point of liquid nitrogen.

Titan has no intrinsic magnetic field, and therefore possesses no large liquid conducting core. Titan does serve as a source of charged particles in Saturn's magnetosphere, but only in the amount of about one ounce per second.

A thick haze obscures all surface features, and three distinct detached haze layers are apparent above the main haze layer. The three layers merge into a darkened hood over the north pole of Titan. Titan's southern hemisphere is somewhat brighter than its northern hemisphere, perhaps as a result of seasonal effects.



Above, **Titan, the largest of Saturn's moons, shows little more than the upper layers of clouds produced by photochemically produced hydrocarbons.**

The Outer Moons: Hyperion and Iapetus

The masses of Hyperion and Iapetus are poorly known, so their densities are quite uncertain. However, it is very likely that they too are mainly water ice. Their surfaces are somewhat less reflective than the inner moons, but still much more reflective than our own Moon, which reflects only 4 per cent of the light it receives from the Sun.

Iapetus is peculiar in that it has one bright and one dark hemisphere. The dark side, which faces in the forward direction as Iapetus circles Saturn, reflects only one-fifth as much as the bright trailing side.

Hyperion has a diameter of about 310 km (190 miles), Iapetus a diameter of about 1,440 km (890 miles).

The Magnetosphere

Although it is only about one-third the size of Jupiter's magnetosphere, the magnetosphere of Saturn is nevertheless an enormous structure, extending nearly a million miles inward from the planet toward the Sun before the flow of charged particles in the solar wind overcomes the effects of Saturn's magnetic field. As in the case of Jupiter's magnetosphere, charged particles in Saturn's magnetosphere are dragged along by the magnetic field and circle Saturn once every 10 hours 39 minutes. At the orbital distance of Titan, these charged particles speed by Saturn's largest moon at more than 193 km (120 miles) per second.

The size of the magnetosphere fluctuates rhythmically as the solar wind increases or decreases in intensity, with the result that at times Titan finds itself outside of Saturn's magnetosphere altogether.

Surrounding Titan and its orbit and extending inward to the orbit of Rhea is an enormous cloud of uncharged hydrogen atoms forming a torus or ring, of ultraviolet-emitting particles. Because they are uncharged, these atoms are not dragged along by Saturn's magnetic field as it rotates, but rather orbit as countless miniscule moons around Saturn.

The rings of Saturn act as an effective shield or absorber of chaged particles close to the planet, but in the process apparently are substantially affected, as evidenced by the "spokes" of fine particles and lightning-like electrical discharges in the ring.

The Editor wishes to thank Nicholas Panagakos of NASA Headquarters, Washington, D.C., and Frank Bristow, NASA Jet Propulsion Laboratory, Pasadena, California, for material contained in this report.

A BRIEF HISTORY OF THE VOYAGER PROJECT - Part 3

By Dr. J.K. Davies.

Continued from March issue

Approaching Jupiter

As Voyager 1 approached Jupiter at the beginning of February 1979 the disc of the planet had been growing steadily in size and soon filled the full field of view of the narrow angle camera. It then became necessary to image the planet by taking photo-mosaics, initially of a 2 x 2 format and later, by February 21st, 3 x 3. Each of the 2 x 2 mosaics were made by shuttering once through each of three filters (violet, orange and green) with the camera centred on four different points. Each set of twelve images was then reconstructed to make a single colour picture of the entire planet's disc. This process would be continued, with ever larger mosaics as the spacecraft closed in on Jupiter.

Although the photographs which were being returned were becoming increasingly spectacular they were more than just pretty pictures to the scientists of the imaging team.

Amongst the specific objectives of the imaging experiment were:

- The study of global atmospheric circulation.
- The horizontal and vertical structure of the clouds.
- Cloud colouration.
- The vertical structure of the upper atmospheric levels.
- Specific features such as the Great Red Spot, white ovals, plumes and hot spots.
- The geology and atmospheres of the Jovian satellites.
- The search for lightning and auroras on the night side of the planet.

In addition to the imaging, other experiments continued to probe the planet and its satellite system. Infra red surveys were made every day and compared with infra-red images taken from Earth. At shorter wave-lengths the ultra violet spectrometer began to zero in on the larger moons. The instrument's narrow field of view was set up near to the satellite and then scanned across and just beyond it, allowing measurements of both the body of the satellite and any nearby gases associated with it.

Toward the end of February members of the scientific community began to arrive at Pasedena to take up residence for the period of closest approach and excitement began to build up at mission control. The engineers of the flight team however continued to guide the spacecraft in towards the planet and made a short firing of the hydrazine thrusters to fine tune the trajectory. By now Voyager 1 was already within the Jovian system having passed the orbit of tiny Sinope some 23 million km (15 million miles) from Jupiter on February 10th.

Two weeks from closest approach the UV spectrometer was scanning across the width of the orbit of Callisto seeking evidence of gaseous clouds associated with some of the inner satellites. The photopolarimeter was also active pointing at the heart of the Jovian system, searching for sodium atoms and mapping the distribution of this element relative to both Io and the planet's magnetic field. Although the most intensive effort would be made around the time of closest approach a few pictures of the major moons were returned starting with Callisto on February 18th. By now Voyager 1 was travelling towards its target at over 13 kilometers per second (nearly 30,000 mph) and still slowly accelerating; maximum velocity at encounter was predicted to be 36 kilometers per second. At this time twin sister Voyager 2 was 100 million km from Jupiter and quietly cruising almost forgotten, through interplanetary space.

Ten days from Jupiter mission controllers stopped thinking that their spacecraft was going to the planet and realised that it was in effect already there. All of the various instruments were now reacting strongly to the Jovian environment in their own way and the magnetometers and plasma instruments indicated

Jupiter from Voyager 1 on 1 March 1979. The region shown is just to the south east of the Great Red Spot. A small section of the spot can be seen at upper left. One of the 40-year old white ovals can also be seen as well as a wealth of other atmospheric features, including the flow lines in and around the ovals. The smallest details in this photo - taken from a distance of 2,700,000 miles (4,300,000 km) - are about 45 miles (80 km) across.

All illustrations Jet Propulsion Laboratory, NASA.

that the crossing of the bow shock wave was imminent. Auroral type activity had been detected around both Io and Jupiter and the planetary radio astronomy experiment was busy investigating the intense radio emissions associated with Jupiter and its electro-magnetic environment.

It is not proposed to describe the Jovian system or the scientific results from the Voyager mission in any detail as these are given excellent coverage in other, more specialist, publications and within *Spaceflight*, but brief mention will be made of some of the significant results. Voyager 1 encountered Jupiter's bow shock, the area where the solar wind responds to the magnetic field of the planet, no less than three times. The first crossing came at about 7 a.m. PST on February 28th, nearly 6 million km from the planet, later that day the solar wind increased squashing the magnetosphere back towards Jupiter and a second crossing was made six hours later. The next day the solar wind had overtaken the spacecraft again pushing the bow shock to within 5.1 million km of the planet.

On March 4th Voyager's narrow angle camera recorded an image on which were subsequently discovered evidence of a previously unknown ring around Jupiter. A time exposure of 11.2 minutes detected a thin, flat ring of particles around the Jovian equator. On the original photograph the ring is split into six and the background star trails appear to oscillate due to a slight nodding motion of the spacecraft. This residual motion is due to the long instrument booms projecting from the vehicle.

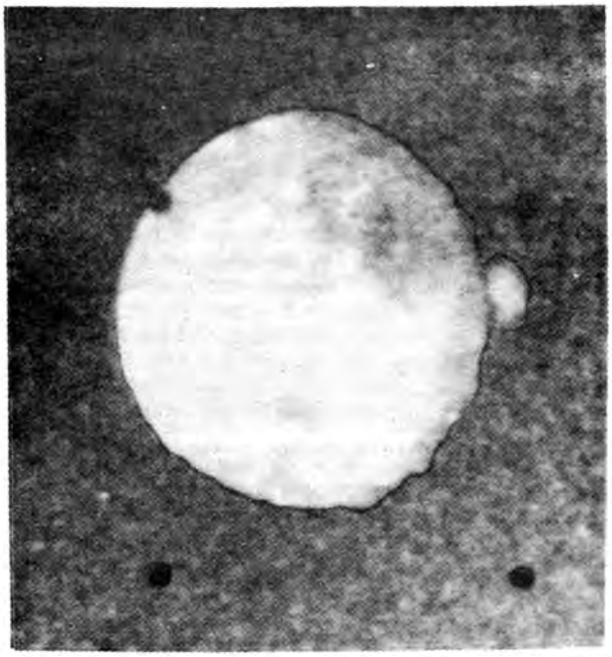
Voyager 1 closed in towards its closest approach, scheduled for the early hours of March 5th PST, the cameras started to zoom in on specific features in the planet's turbulent atmosphere, examining some of them several times to search for short term changes. The Great Red Spot, for example was imaged several times, the final mosaic on the inbound leg being made about 8 hours from periapsis and consisting of no fewer than eighty one frames. A few hours before periapsis Amalthea, a tiny ellisodial moon with a major axis only 270km long and just over 100,000 km from Jupiter, was photographed and shown to reflect 50% more red than violet light. Soon after, the cameras were turned on the innermost of the large moons and an imaging mosaic covering about one third of the visible side of Io was made. Intensive studies of Io continued as Voyager made its closest approach to Jupiter, and then the imaging data was directed to the onboard tape recorder since Earth occultation was rapidly approaching.

Surface of Io

Io, innermost of the four major satellites, was generally expected to be similar to Earth's Moon with an old and cratered surface but photographs taken at long range showed Io to be unusually smooth. As the distance to the satellite decreased dark spots with faint outer rings were observed and these were assumed to be impact craters. As resolution improved however it became obvious that this was not the case since no impacts could be detected amongst a host of unusual landforms. Just before the closest approach to Io a circular feature 50 km in diameter and surrounded by a radiating pattern of flow was observed. It began to look as if Io had a recent history of extensive vulcanism which had overlaid the ancient terrain. Such activity had been predicted in a paper published only days before by Peale, Cassen and Reynolds. Seldom in the history of science can such spectacular confirmation of a prediction have occurred so soon after publication. Eventually more than one hundred of the apparently extinct volcanoes would be identified.

The surface of Io was also revealed to be extremely cold (60 to 100 K) and brightly coloured. The most likely cause of this colouration was thought to be due to the variety of chemical forms exhibited by the element sulphur at these temperatures.

Some three and a half hours after priapsis the spacecraft, as seen from Earth, slipped behind the planet allowing a series of radio science and UV investigations. Before occultation the S and X band radio transmitters were adjusted to equalise the signals through the atmosphere. The transmission characteristics of the atmosphere and the relative distortion of the two different frequencies as the signals passed through the increasing depth of gases allowed studies to be made of the ionosphere and the nature of materials in the clouds.



The Voyager 2 picture of Io was taken in ultraviolet light at a range of 2,900,000 miles (4,700,000 km). The bright spot on the right limb is one of the volcanic eruption plumes first photographed by Voyager 1. The plume is more than 124 miles (200 km) high.

JPL/NASA

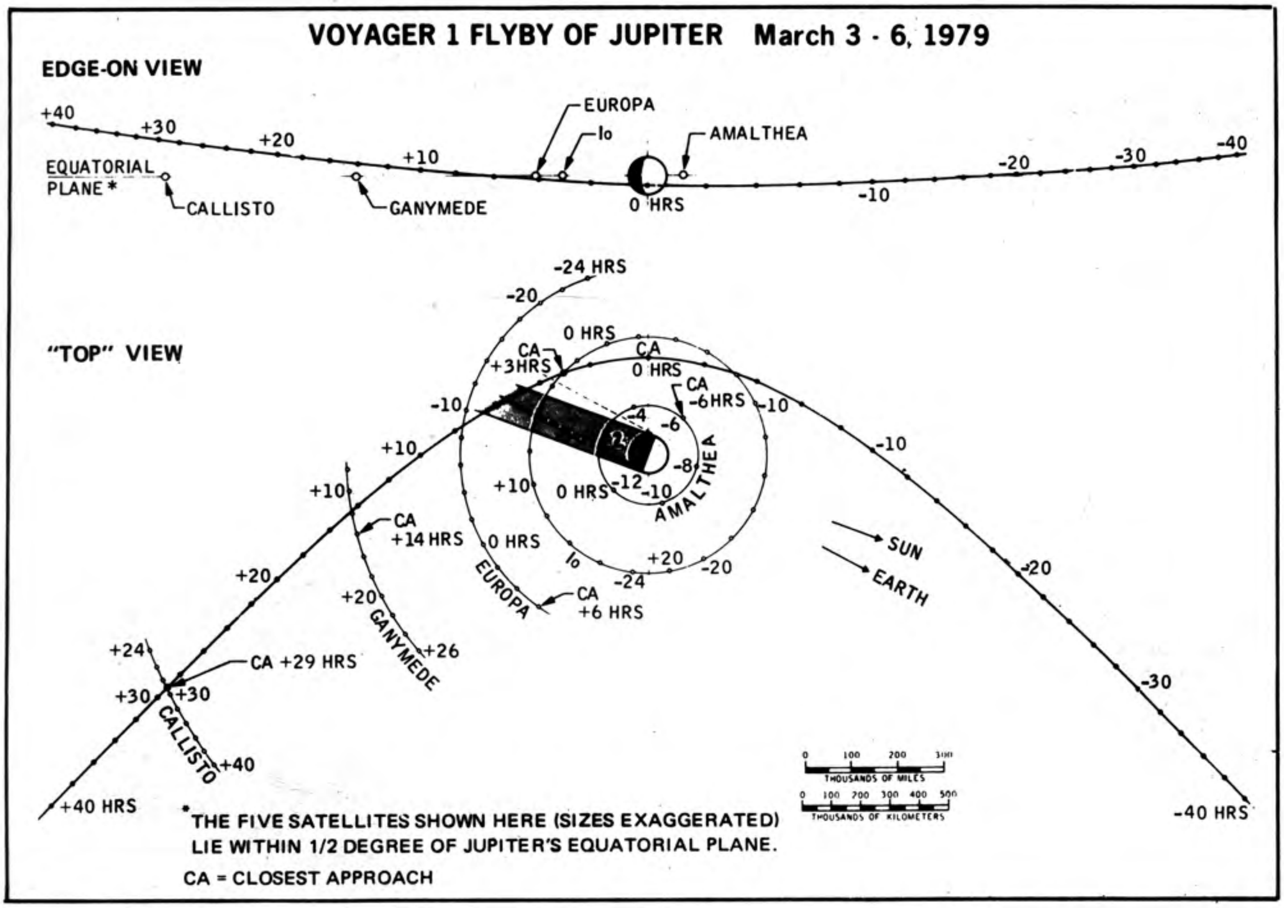
Fifty-three minutes later, and for the first time since separation from the launch vehicle some eighteen months before Voyager 1 lost sight of the Sun. As the sunlight became increasingly dimmed by the clouds the ultra violet spectrometer was used to probe the composition and temperature of the atmosphere and was able to detect a variety of chemicals which had eluded the less sensitive instruments on the earlier Pioneer spacecraft. Whilst occulted by the planet, Voyager made its closest approach to Europa although even then the flyby distance was in excess of three quarters of a million km. Photos revealed a body which was lightly coloured and globally of low contrast. In addition the moon was covered by a number of intersecting streaks some tens of kilometers wide and extending over a thousand kilometers or more. Since at this range the resolution was equivalent to a view of Earth's Moon occupying only one third of a domestic television screen little else could be discerned initially. Voyager 2 was planned to make a much closer approach to Europa on its inbound passage through the Jovian system later in the year.

Both Sun and Earth occultation lasted about two hours, and then the spacecraft began to pull away from the planet and attention turned towards the satellites Ganymede and Callisto.

Pictures of Ganymede revealed a surface remarkably similar to the Earth's moon but, as the resolution improved, peculiar grooved terrain, consisting of parallel ridges and troughs up to 15 km wide and hundreds of km long were observed. Extensive coverage of the Jupiter-facing side of Ganymede was achieved, the opposite hemisphere would be studied by Voyager 2. The closest approach of Voyager 1 to Ganymede was 112,030 km allowing a best surface resolution of 2km.

Features on Callisto

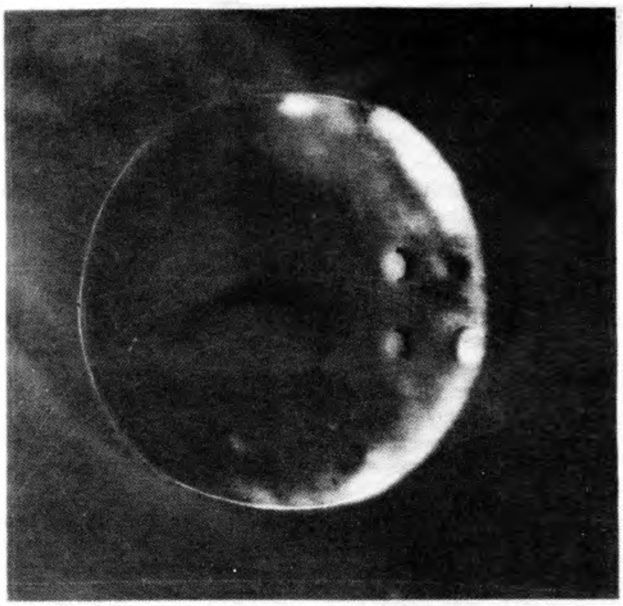
The final satellite to be examined in detail by Voyager 1 was Callisto, outermost of the Galilean moons, orbiting at a mean distance of 1.8 million km from Jupiter. The Jupiter-facing



hemisphere of Callisto was also imaged at high resolution, between two and seven km per line pair, and showed itself to be different again from its companions. The spacecraft flew within 124,000 km of Callisto and showed that the surface was very heavily cratered with no evidence of mare type basins as observed on Earth's moon. In addition to the craters a massive system of concentric rings was discovered in the crust. Centred on a bright circular region 10 degrees North of the equator, these rings stretched out to a distance of 1,500 km. As Voyager 1 receeded from Callisto on the afternoon of March 6th the intensive activities of the near encounter phase began to draw to a close. The spacecraft would continue to look back upon Jupiter for several weeks yet and analysis of the data returned during closest approach had hardly begun. Work began immediately to analyse as much of the data as possible in the short time remaining before Voyager 2 arrived, thus allowing maximum benefit to be obtained from the second spacecraft.

It was during this post-encounter period that examination of a long range photograph of Io, taken for navigation purposes, revealed a curious asymmetry. The photograph had been over exposed to bring out details of the background stars and JPL engineer Linda Morabito noticed an unusual umbrella shaped blob on the limb. After attempts to explain it away as an artifact had failed, it was realised that one of Io's volcanoes had been caught in the act of erupting. What else could have thrown an enormous cloud 270 km above Io? Once the reality of the feature was established a major effort was put under way to locate any other plumes and no less than a further seven active volcanoes were discovered on a body both smaller and colder than Earth. Io was thus revealed to be the most volcanically active body in the Solar System discovered to date.

Thus as Voyager 1 left Jupiter behind and began the long journey towards Saturn, over twenty months away, it had successfully met all of its first objectives and surpassed even the most optimistic dreams of its creators. By March 15th over



Callisto from a distance of about 5,000,000 miles (8,046,500 km).
JPL/NASA

15,000 photographs of Jupiter and its satellites had been returned along with a wealth of other scientific data. Robert Parks of JPL described the mission as "spectacularly successful" and NASA administrator Robert Frosch said "Superlatives fail us. The data speaks for itself". Even as he spoke Voyager 2 was closing in on Jupiter and was now less than four months away.

[To be continued]

SPACE REPORT

RECOVERING THE SHUTTLE ORBITER

Special precautions have been taken at Edwards Air Force Base, California, where the first four flights of the Space Shuttle "Columbia" are due to end. Immediately the spacecraft lands ground team members wearing "SCAPE" suits that protect them from toxic chemicals will approach the spacecraft as it stops rolling.

The ground team first take sensor readings to ensure that the atmosphere in the vicinity of the orbiter is not explosive. In the event of propellant leaks, a wind machine truck carrying a large fan will be moved into the area to create a turbulent air flow that breaks up gas concentrations and reduces the risk of explosion.

An air conditioning purge unit is attached to the orbiter so cool air can be directed through the orbiter's aft fuselage, payload bay, forward fuselage, wings, vertical stabiliser, and orbital manoeuvring system/reaction control system pods to dissipate the heat of entry. This heat, if not dissipated, will "soak" to the orbiter systems within 15 minutes of landing.

A second ground cooling unit is connected to the spacecraft Freon coolant loops to provide cooling for the flight crew and avionics during post landing and system checks. The spacecraft fuel cells remain powered up at this time. The flight crew will then exit the spacecraft and a ground crew will power down the spacecraft.

Within one to two hours the spacecraft and ground support equipment convoy will be ready to move the spacecraft to the service area at NASA's Dryden Flight Research Center at Edwards. After detailed inspection and preparations at DFRC, the "Columbia" is ferried by the Boeing 747 Shuttle Carrier Aircraft to the Kennedy Space Center.

When the spacecraft lands and completes its runout at the KSC, the same procedures as at Edwards Air Force Base are followed with the exception that only one hour will be required before the spacecraft and convoy are ready to move to the Orbiter Processing Facility (OPF).

In later missions, the orbiter must be refurbished and prepared for another launch within 160 hours (14 working days). This short turnaround decreases the maintenance cost (part of the cost per flight), decreases the number of orbiters and support elements needed, and increases the utilisation rate of each orbiter.

The spacecraft is towed to the Orbiter Processing Facility where it is safed (fuel and oxidiser systems drained, tanks purged and ordnance removed). The OMS and RCS pods are removed, refurbished if required and reinstalled and other vehicle maintenance performed. The payload is then installed and spacecraft functioning verified. Activity in the OPF will take about 96 hours.

In the meantime, a new set of solid rocket boosters and external tank will have been stacked and mated on the mobile launch platform in the Vehicle Assembly Building (VAB). The spacecraft is then towed to the VAB and mated to the external tank, shuttle connections and the integrated vehicle are checked and ordnance is installed. Activity in the VAB is due to last about 39 hours.

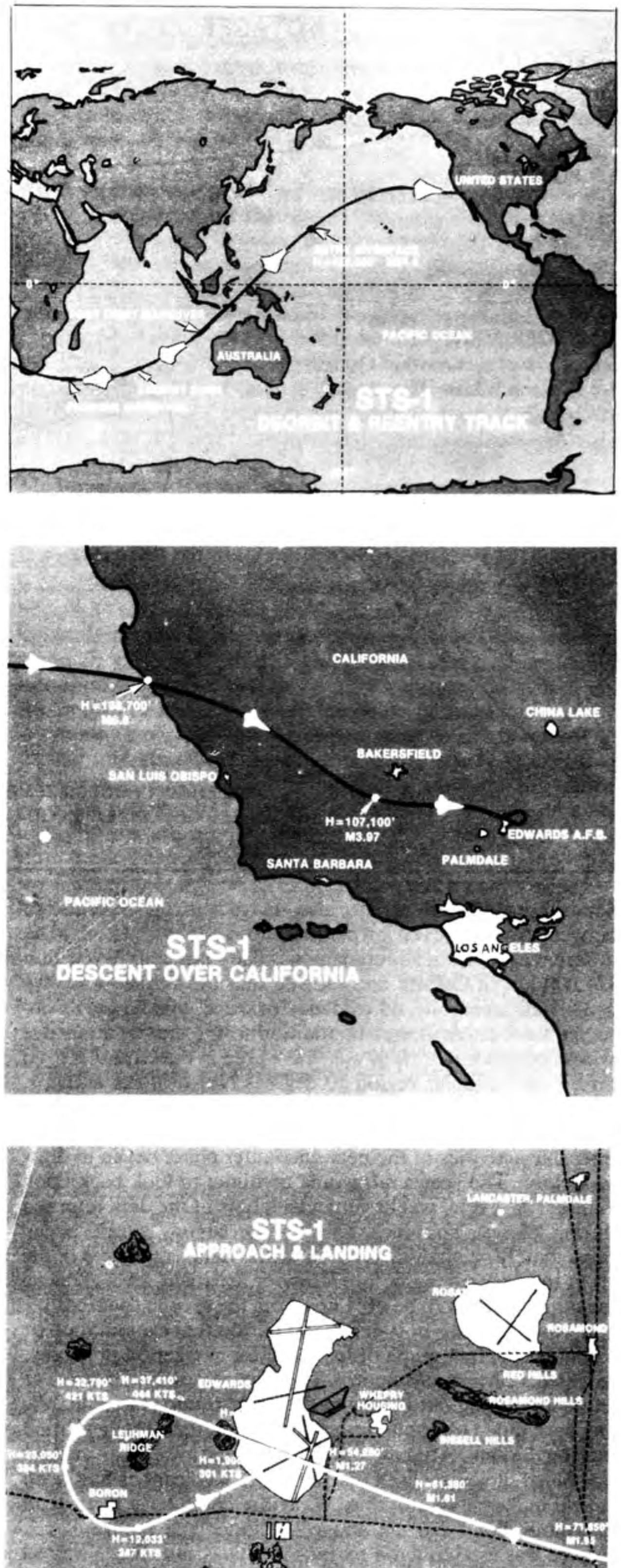
The giant crawler then moves the entire Shuttle stack 3½ miles to Launch Complex 39A where connections are made and servicing, checkout and pre-launch activities are conducted. This takes about 24 hours.

The vehicle is then ready for launch within two hours.

NASA has, of course, prepared a number of alternative landing sites to cater for emergencies. Contingency sites are at Northrup Strip, White Sands, New Mexico; ROTA Naval Air Station, Spain; Kadena Air Force Base, Okinawa, and Hickam Air Force Base, Hawaii.

In the event of a landing at any one of these sites, a crew of eight will immediately move to the landing site to assist the astronaut crew. Their main task will be to prepare the orbiter for loading aboard the Shuttle Carrier Aircraft for transport

Continued on page 133



The first four flights of the Space Shuttle are scheduled to return to Edwards Air Force Base, California. These diagrams show (top) the planed de-orbit and re-entry track; (centre) the descent over California, and (bottom) approach and landing.

NASA

HIGHLIGHTS

Cosmonaut Alexei Yeliseyev, Flight director of Salyut 6, says "structural elements for future orbiting stations were cast in space during expeditions to Salyut 6... the units were made by injecting liquid polyurethane and a foaming agent into a mould under pressure. The result was a rigid and sufficiently strong material with closed pores and a smooth surface, which could be used, for instance, in building the enormous panels of solar cells which might be needed by future power stations in space." Ref: *Soviety Weekly*, 17 January 1981.

Work on India's second Bhaskara Earth resources satellite has began in Bangalore. The satellite will have three microwave radiometer channels, one more than the original. The extra channel will permit precise measurements of water vapour in the atmosphere. Launch is scheduled by a Soviet C-1 rocket in the second half of next year.

The world's longest-life space probe Pioneer 6 was still working last December, marking the 15th anniversary in space. Apart from making the first detailed measurements of the tenuous gas in space, Pioneer 6 observed the Sun and its corona. Sister-craft Pioneers 7, 8 and 9 also continue to supply information about solar activity.

A Space Museum with the shape of "an interplanetary space station' is under construction at Stellar town near Moscow where Soviet cosmonauts are trained. The building, which has a capacity of 2,260,000 cubic feet (64,000 cubic metres), will house several thousand exhibits collected over the 20 years since Yuri Gagarin made the world's first space flight on 12 April 1961. On display will be spacecraft, spacesuits and cosmonauts' personal items. Visitors will be able to make a simulated flight into space.

Soviet scientists have prepared two soft-landing spacecraft for launching from the Baikonur cosmodrome by Proton D-1-e rockets when the Venus "window" opens in November. They will have equipment capable of drilling into surface rock and depositing soil samples into a robot laboratory for chemical analysis by an X-ray fluorescence device. The spacecraft expected to reach Venus in March/April 1981, will also embody TV cameras and other scientific equipment.

NASA engineers at the Goddard Space Flight Center are developing a refrigeration system for space operations that could lead to commercial development of pumps, motors, compressors and other mechanical devices which would operate virtually without wear. The new development, called "a significant technological advance", eliminates the frication and, therefore, the wear associated with moving parts. The piston and displacer in the NASA cooling system are suspended in a magnetic field, permitting the parts to move without touching the sides of their housing. Goddard engineers say that could increase system lifetime for operation of astronomical and Earth-watching instruments in space from the present six to 10 months to three to five years.

A new high altitutde aircraft designed to carry nearly two tons of instruments 13 miles (21 km) high was delivered to NASA's Ames Research Center last month. Designated the NASA ER-2 (for Earth Resources), it will augment research programmes being carried out by two Lockheed U-2 aircraft also at Ames. The ER-2, built by Lockheed, is similar to the U-2 but larger and has a greater payload, range and altitude capability. The single-sea jet aircraft will cruise as high as 71,000 ft (21,600 m) at a speed of 478 m.p.h. (770 km/h) for as long as 12 hours.

Boeing research scientists have produced a thin film (copper indium selenide/cadmium sulphide) solar cells with an energy conversion efficiency of 9.4 per cent. Thin film cells have the potential for simpler production techniques, using less material and costing less than the single crystal silicon cells commercially available today.

A new communications satellite Earth station in Poland, operating as part of Intelsat, will provide the first direct satellite communications between that country and North America. The station is being built at Psary, about 110 miles (180 km) south of Warsaw, by General Telephone & Electronics, and will be able to transmit and receive televison, telephone and telex communications. It will operate initially with 18 full-time voice circuits between Poland and the United States and 15 circuits between Poland and Canada. In addition Poland will be able to communicate directly via satellite on a "demand assigned" basis with more than 25 countries in Africa, Europe and Central and South America.

Continued from page 132

back to the Kennedy Space Center. Outside the United States, personnel at the contingency landing site are given minimum training on safe handling of the orbiter with emphasis on crash rescue training, how to tow the orbiter to a safe area, and prevention of propellant contamination.

The fifth and subsequent flights of "Columbia" are scheduled to land at the Kennedy Space Center.

MORE SKYLARKS FOR GERMANY

The German Aerospace Research Organisation, DFVLR has placed a £450,000 order with British Aerospace Space & Communications Division for the supply of five Skylark type 7 research rockets. All five will be launched in Germany's Texus project. Texus is part of the German programme of materials research and space processing under microgravity conditions. The purpose of the programme, which is funded by the Ministry of Research and Technology (BMFT), is to achieve a better understanding of scientific and technological phenomena and so improve technical processes and products.

The Skylarks will be delivered in component form from Bristol Division between 1981 and 1983. They will be prepared and launched by DFVLR from Esrange at Kiruna, Sweden. DFVLR has launched with considerable success 25 British Aerospace Skylarks, three of which were in the Texus materials science programme.

A Skylark 7 comprises a Goldfinch boost motor with a Raven 11 second stage motor. The rocket vehicle enables experiments to be exposed to microgravity for at least six minutes and is but one of a variety of rocket motor and payload configurations which can be tailored to specific scientific requirements.

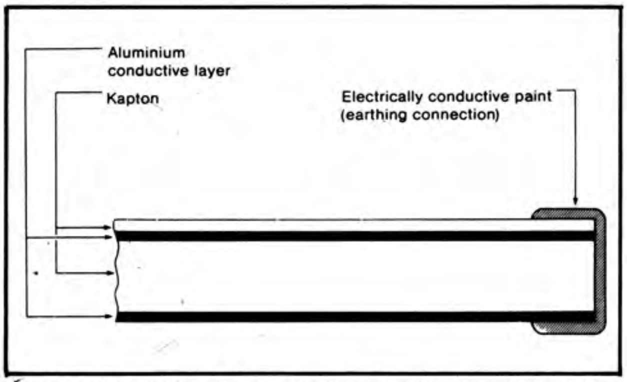
PROTECTION FOR SATELLITES

Problems associated with the build up of static charges on satellites have been known as long as space launches have been taking place, writes Robert Christy. At the beginning of 1979, the US Air Force launched its SCATHA (Spacecraft Charging At High Altitude) satellite to investigate the phenomenon in the region of space used by geostationary satellites. At this height showers of electrons with energies up to 35 keV are trapped by the Earth's magnetic field, and a satellite encountering these can experience a static charge build up as high as 20,000 volts on its outer skin.

If the charge reaches the breakdown threshold of the satellite's covering material, spontaneous electrical discharges occur which can cause physical damage as well as introducing spurious signals in electronic circuits. On at least two occasions, satellites may have been lost as a result of the effects of such discharges, which are particularly dangerous while essential manoeuvres are being performed. At best, satellite operations may be disrupted for a period while ground controllers devise ways of reversing the damage.

British Aerospace has developed and applied for patents on a new composite material which should overcome some of the static problems. It is a sandwich made up of Kapton - an insulator - and aluminium.

One problem which engineers have overcome is that good electrical conductivity, which is required by the new material, normally goes hand in hand with good thermal conductivity, an



Cross section of the new electrically conductive thermal insulating space blanket developed by the Space and Commmunications Division of British Aerospace.

undesirable property in satellite covering material. The new blanket has good electrical conductivity while maintaining the thermo-optical properties of conventional materials.

A 3 mm thick primary layer of Kapton has a thin layer of aluminium vacuum coated or sprayed onto it, a further thin layer of Kapton is overlaid on the outside surface, and a second aluminium layer forms the inside surface. The two conducting layers are earthed on the satellite's structure. An electron entering the outer layer is conducted away by the first aluminium coating. Should it have sufficient energy to penetrate the aluminium, it will be captured by the second layer. This second layer also has radio frequency insulation properties which can be varied by using different thicknesses; the Kapton layers can also be varied to give different thermal and optical properties.

Extensive tests of the material by the UK Atomic Energy Authority at their space simulation facility showed it to be capable of withstanding the effects of energies up to 30 keV, at bombardment rates 20 to 30 times those expected under normal orbital conditions.

MILITARY MAN-IN-SPACE

Comparing the potential of space for military operations to that of aviation prior to World War I, a top Air Force planner recently urged that the United States move ahead at full speed towards the development of an operational manned military capability in space, writes Gerald L. Borrowman.

"I can't overemphasize the utility that space systems have in supporting our military forces," Lt. Gen J. F. O'Malley - DCS, operations, plans and readiness for the Air Force - said recently. This is recognised by the Air Force, he said, which is "Gearing up to accelerate the exploitation of space over the next few years "via the Space Shuttle".

However, emphasis must now be placed on space operations, not merely R & D, he continued. There is a misconception that space is an R & D arena only, but "the use of space within the military has become too important to allow such misconceptions to continue. It is time to get the operators more involved with space activities . . .

"The U. S. must recognise that space is no longer an R & D environment only, but rather an operational medium as well," he said. "We must apply the same considerations to space systems as we do for other operations. We must design space assets as we do other operations. We must design space assets and structure their supporting organization in a manner responsive to the needs of operational forces - and integrate them into those forces - to allow field commanders to be confident that space capabilities will be there when they are needed".

Despite the fact that "Numerous treaties have been signed and policy statements made which explicitly recognise the peaceful aspects of space," O'Malley said, "the potential for space to become a more hostile environment is increasing". The reason: First, because space provides "increasingly important support - some would say a decisive edge - to military forces", and second, because "the technology for space conflict is available.

"While there are undoubtedly well intentioned people who decry what they regard as the potential for militarisation of a pristine frontier, history teaches us that each time a new medium is opened to man it is exploited to gain a military advantage," the General said. "The course of world affairs has repeatedly been altered by the nation which first grasped the advantages offered by developing the military potential of the newest medium . . ."

As in World War I, when the air "started out as a sanctuary, space has started now the same way," he said, but "has rapidly become what some are calling 'the fourth military arena'.

Like the early aviators who waved at each other during reconnaissance missions," he said, "the handshake of Apollo-Soyuz (the joint U. S./Soviet space missions in 1975) are likely to be overshadowed by increased military competition in space".

The most important reason why America's military space activities will continue to grow, he said, is because of the "routine presence of man in space that the Shuttle will bring.

"I know there are those who see people as a liabilty in space - but frankly, I don't share that view. In fact, on this issue, I feel an undefinable, but very real sense of urgency - a basic premonition that in some future period we are going to look back and wonder why we were so slow to comprehend the value of man in space . . ."

This contrasts with the Soviet record of "an agressive man-in-space programme - one they apparently believe is paying enough dividends to warrant the steadily increasing cost," he said.

The General said he hopes that the advent of the Shuttle "will regain the initiative for the U. S. in employing man in space".

However, at present, the Soviets currently have:

1. The first unmanned ferry and Space Station re-supply vehicle (Soyuz).
2. The most man-hours in space.
3. The longest duration continuously manned space system (Salyut 6); and,
4. The only operational Anti-Satelite (ASAT) system.

Among other things, O'Malley urged that military astronauts return to the military after they complete their tour of duty with NASA to provide expertise for military space operations.

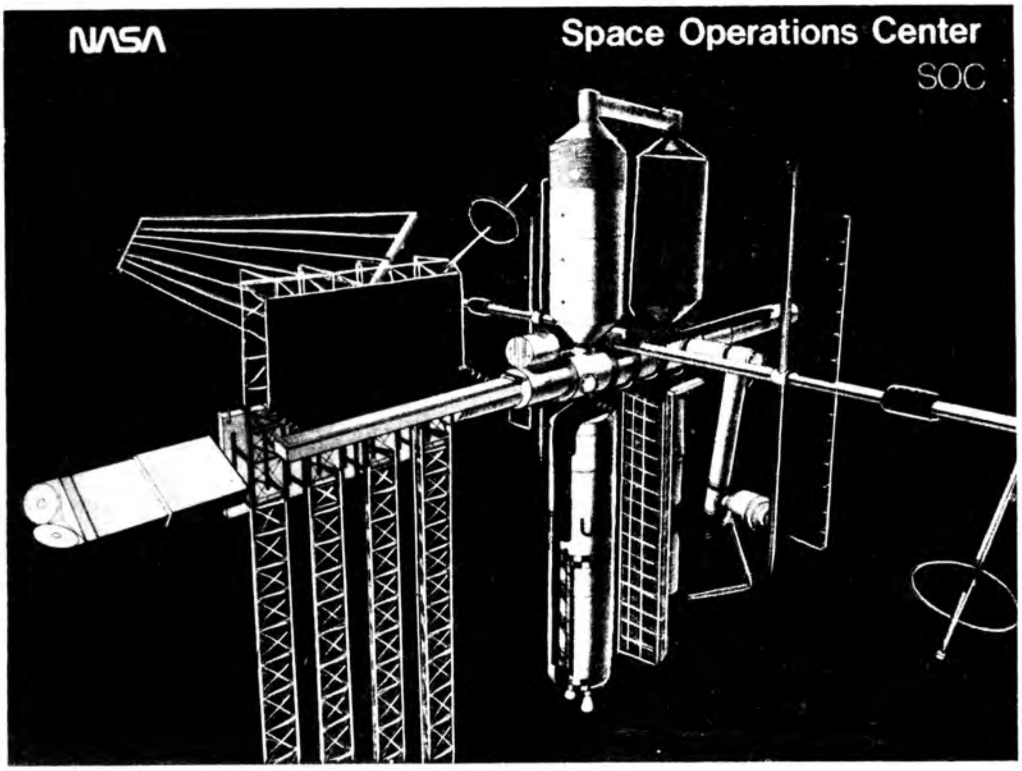
SPACE OPERATIONS CENTER

Boeing Aerospace Company has been given the task, under a 12-month, $400,000 contract, of defining a manned Space Operations Center (SOC) which could be assembled some 200-250 miles (321-402 km) above the Earth. The study is being made in conjunction with NASA's Johnson Space Center in Houston.

The SOC would serve many purposes. Free-flying satellites could be tended and space-based vehicles could be serviced, launched and recovered. The Centre would be permanently manned reducing dependance on Earth for control and re-supply.

The scheme involves using low Earth orbit as an operational staging post, like a base camp for a mountain climb. For example, the platform could be used for refuelling orbit transfer vehicles on missions to Clarke orbit or into deep space.

Boeing explains: "The Shuttle would be used for launch and assembly of the Space Operations Center. Modules of the



Space Operations Center studied by the Johnson Space Center, Houston, Texas. The objective is to develop Space Shuttle techniques for building manned space platforms in Earth orbit using structural members fabricated from raw stock or pre-assembled folded members - also the assembly of these members with subsystem components making up complete space systems. Space factory tools include attachment and alignment fixtures, beam-builders, end-effectors and manned remote-controlled work stations. Similar techniques are now being studied under contract to NASA by Boeing Aerospace.
NASA

Center would contain living quarters, service compartments and warehouses. Two living modules accommodating a crew of eight would be 40 to 50 ft (12.2 to 15.2 m) long by 14 ft (4.26 m) in diameter, about the size of a large mobile home.

To meet operational objectives of the Center, a space construction facility and flight support facility also would be required. Power would be provided by two boom-mounted solar arrays.

Should NASA gain approval to build a Space Operations Center, a start could be made with an "interim station" needing a crew of four. It could be constructed from modules launched by two or three Shuttle flights in the late 1980's.

PUBLIC AWARENESS OF SPACE

A study was recently conducted in the Chicago, Illinois, area to investigate general public awareness and attitude towards the U. S. Space Programme, writes Gerald L. Borrowman. A two-page questionnaire was designed on the basis of a series of pilot tests, and used as the primary instrument to measure response.

The current level of public awareness and attitude towards the U. S. Space Programme is considerably more diverse and controversial today than it was ten years ago. The public zeal, enthusiasm and pride which arose during and in the wake of the first lunar landing has dissipated into an unknown state, with elements of extreme pro and anti-space expressions, ambivalence and apathy.

The Apollo programme was reinforced by a political and public commitment to a recognisable goal. Little, if any effectual public opposition existed. Special interest groups were relatively non-existent and those groups which did exist were not sufficiently involved with policy to present any opposition.

Today, however, a comparable goal is absent and the public is unable to relate to a single, identifiable objective. Special interest groups opposed to space programme proposals are growing in number, particularly with respect to environmental issues and space industrialisation.* The most newsworthy issue attended to by the media was Skylab, tumbling to Earth without a trail of acknowledged achievments and advancements which, in reality, marked the project out as one of man's greatest achievments.

As a consequence of these disparate conditions, there is an increasing interest in and concern for the public's attitude towards the space programme. Several pro-space organisations advance the objective of educating the general public about the space programme and its benefits to mankind in attempts to rejuvenate public support.

The study found that a general attitude towards the space programme is correlated with knowledge of space-related activity, benefits perceived as a result of the space programme, the perceived income of the space programme, and the degree to which the space programme was recently discussed by the media.

Results of the study suggest that unless space programme activity is a salient issue and of perceived value to the general public, selective exposure to other newsworthy information precludes attention to information disseminated about the space programme.

The study suggested that "reaching the general public" requires a space programme proposal which is of value to the problems of concern - an economic or energy solution and perhaps again, "a race-in-space game with the Soviet Union".

* *Why this should be is difficult to understand as, in the long run, space industrialisation can only benefit the Earth's environment.*

SPACEPORT POSTAL SERVICES

The John F. Kennedy Space Center, Florida, in cooperation with the United States Postal Service, is offering a cancellation service to interested philatelists for the space flight programme at Kennedy. Philatelists who wish to avail themselves of this service may do so by following the procedures outlined below:

● Specify the event for which you wish this service. There is a limit of five covers per customer per event.

● All covers must be self-addressed and bear at least first class postage or proper postage for international mail placed three quarters of an inch down from the right top of the cover. Evelopes should contain a filler not to exceed the thickness of a postal or computer card to assure a clear cancellation.

● All inquiries must be accompanied by a stamped, self-addressed envelope.

● Request for service must be received at least five days prior to an event, but no earlier than 30 days before. Requests should be sent to: Chief, Mail and Distribution Services, SI-SRV-1M, Kennedy Space Center, FL 32899.

Services not provided are:

● Requests for personally autographed covers, or for carrying covers on board during flight or preflight activities.

● Cachet service (rubber stamp) for such major events as the first launch of the Space Shuttle.

● Hand-back service.

Since the Kennedy Space Center Post Office is open only Monday through Friday, excluding legal holidays, envelopes cannot be cancelled on Saturday or Sunday. Cancellations for minor tests cannot be given because access to these schedules is not available.

NASA RECALLS NAUGLE

Dr. John E. Naugle, former Chief Scientist of NASA, returned to the space agency on a temporary basis as Acting Chief Scientist on 1 December 1980, writes Gerald L. Borrowman. Naugle was recalled in the role of principal scientific advisor to the NASA Administrator and will continue as a member of the NASA Advisory Council with the responsibility for planning long-range Solar System exploration and for looking at other possible long-range goals for NASA.

Naugle retired from NASA in June 1979. He joined the space agency at the Goddard Space Flight Center in 1959 as head of the Nuclear Emulsion Section. In 1961 he became Chief of Physics and Astronomy Programmes in the Office of Space Science at NASA Headquarters and from June 1962 until May 1966 he was director of Physics and Astronomy Programs in the Office of Space Science and Applications.

He was appointed Associate Administrator for Space Science and Applications in 1967 and became Deputy Associate Administrator of NASA in 1974. Naugle assumed duties of Acting Associate Administrator in April 1975 and Associate Administrator of the agency in November 1978. He was named Chief Scientist in November 1977.

CHECKING OUT THE SUN

Using a new type of measuring device flown in space for the first time, a NASA satellite has detected small changes - over periods of days to months - in the brightness of the Sun.

Detection of even the slightest change in the amount of light and heat energy emitted by the Sun is important because, if a trend were to continue for several years, it could produce major alterations in the Earth's climate. Measurement of such trends might enable scientists to predict future climate changes.

Fluctuations of about one-tenth of 1% were seen several times by an experiment aboard the Solar Maximum Mission satellite last year. These fluctuations in solar radiation correspond to a change of up to 10 degrees Celsius in the Sun's average temperature of about 5,700°C.

The newly-measured changes in the Sun's output of energy may be related to sunspot or solar flare activity, according to meteorologist and physicist Dr. Richard C. Willson of the Jet Propulsion Laboratory, who developed the instrument to measure the Sun's radiance for the Earth-orbiting satellite.

The instrument, called an Active Cavity Radiometer Irradiance Monitor, one of seven experiments on the satellite, is capable of detecting changes in the Sun's release of energy as small as one thousandth of 1 percent. The instrument measures a very broad range (X-rays to radio waves) of the radiation that impinges the Earth's upper atmosphere. This represents well over 99.9% of the total solar radiation reaching Earth.

Theoretically, an increase or decrease in the Sun's release of energy - as little as 0.5 percent per century - can produce profound changes in Earth's climate. It is estimated that a drop of only 1% in the Sun's output of radiation would decrease Earth's mean global temperature by more than 1°C. The entire Earth would be covered with ice if the Sun's radiation decreased by only 6%.

The entire history of humankind, lived out in the last several million years, has occurred during abnormally cold times. There is evidence that the Earth has been growing colder for about 90 million years, and scientists believe the average global temperature may drop 10 or more degrees in the next several million years.

One-hundred-fifty million years ago, Earth was approximately 8°C warmer than it is today. Since then, numerous warming and cooling climatic cycles have occurred. These cycles, which occur with frequencies ranging from 22 years to millions of years, have caused ice ages, ranging in severity from major glacial epochs to "little ice ages."

The last "little ice age," which began in the mid-17th century and lasted through the mid-19th century, was marked by a one-and-a-half degree drop from the present mean global temperature of about 14°. This slight change in the Earth's average temperature resulted in an observable increase of glaciation in the Alps.

SPACE EYE ON GYPSY MOTH

A three-year pilot programme to demonstrate the feasibility of using Landsat satellite data to detect and monitor gypsy moth damage in forests has been started by NASA and the Pennsylvania Department of Environmental Resources.

The gypsy moth caterpillar, which mostly inhabits the northeastern United States, feeds predominantly on the leaves of hardwood trees, such as oak and maple. In 1980 alone, the caterpillars defoliated 178,062 hectares (440,000 acres) of hardwood forests in Pennsylvania. Over the past 10 years, gypsy moth damage to the hardwood forests of Pennsylvania has been estimated at $32,000,000.

The pilot programme uses multispectral scanner data from NASA's Landsat to examine hardwood forests conditions before and after defoliation occurs. This procedure allows forested areas exhibiting gypsy moth damage to be identified and located on the satellite image so that analysis of subsequent satellite imagery can be concentrated on monitoring those areas affected.

By updating the satellite imagery, foresters are able to identify which forested areas are infested, as well as which areas to isolate for pest management activities. Officials expect satellite monitoring techniques to improve on conventional aerial sketch mapping methods which are "inadequate, costly and nonstandardised."

Results of the pilot programme will be used to inform other states in the eastern United States of techniques which they can employ to control the southwestward spread of the gypsy moth in hardwood forests since it was initially mapped in New England in 1910.

During the programme, the Landsat imagery will also be used to generate a mosaic of the entire Keystone State. Each Landsat image covers an area 300 km (115 miles) square. The Landsat multispectral scanners, which are used to collect this data, measure green, red and infrared light being reflected off the surface of the Earth by the Sun. These measurements are then transformed into images and recorded on digital tapes by computer processing for future analysis.

SPACE SYSTEMS OPERATED AND PREPARED BY DEVELOPING COUNTRIES

Compiled by Theo PIRARD, Space Information Center, Pepinster, Belgium.

COUNTRY	SPACE SYSTEMS	ACTUAL STATUS	PLANNED OR IN PROSPECT
ALGERIA	Domestic communications	1 transponder lease from Intelsat system for TV and communications services - network of 15 Earth stations operational since 1975, built by GTE.	Improvements and extension of the services developed by the initial ground segment.....
ARGENTINA	Earth resources observations	1 Landsat receiving station established at Mar Chiquita and provided by MBB.	Possibility of cooperation with Brazil for the development of remote sensing satellites....?
BRAZIL	Launch systems and facilities	Indigenous Sonda rockets launched from Barreira do Inferno with payloads up to 600 km altitude.	Plans to develop a Sonda-type rocket as satellite launch vehicle (for small spacecraft).
	Domestic communications	2½ transponder leases from Intelsat system - 8 Earth stations as initial network.	Brazilian communication satellite studied since 1970. Final decision expected in 1980?
	Earth resources observations	1 Landsat receiving station operated at Sao Paulo.	Proposal for 1985 of a Brazilian observation satellite.
CAMEROON	Domestic communications	Experiments with French-German Symphonie communication satellite.	Request for proposals in order to modernise very rapidly the TV network.
CHILE	Domestic communications	1/4 transponder lease from Intelsat - 1 Earth station.	Member of the Andean Satellite System (ASETA) to become operational during the 1980's.
CHINA (P.R.)	Launch systems and facilities	Two different models of satellite launch vehicles based on ballistic missiles - 8 space - craft successfully launched from Shuang Cheng-tze complex.	A third improved version, called "Long March 3", for geostationary satellites launchings is under development... Also plans for more powerful launch vehicles for manned operations. 2 indigenous technological communication satellites planned in 1981 for launch on the "Long March 3" model. Two US television broadcasting satellites launched by the Space Shuttle. Development of an indigenous Earth remote sensing satellite (to be launched after 1985?)
	Domestic communications	About 10 indigenous Earth stations, tested with French-German Symphonie communication satellite; member and user of the Intelsat system.	
	Earth resources observations	Agreement with NASA for the establishment of a Landsat receiving station near Beijing.	
COLOMBIA	Domestic communications	1/4 transponder lease from Intelsat - 2 Earth stations.	Study of the Satcol satellites for TV and telecommunications services in South America.
EGYPT	Earth resources observations	National center at Cairo for use of remote sensing data.	Planned regional center for image processing, photo reproduction and interpretation training (USAID Program).
GABON	Domestic communications	Exchange of TV programmes relayed byFrench-German Symphonie-communication satellite - 1 Earth station.	Great interest for TV broadcasting system by satellite.
INDIA	Launch systems and facilities	Development of solid sounding rockets and of a 4-stage satellite launch vehicle, called Rohini. Launchings made from Sriharikota island of small technological satellites.	Plans for the development of heavier and more powerful Rohini satellite launch vehicles, in order to put next Indian application spacecraft into polar or geostationary orbit.
	Domestic communications	1/4 transponder lease from Intelsat - 7 Earth stations. In 1975/76, Satellite Instructional Television Experiment (SITE) with NASA ATS 6. In 1977/79, Satellite Telecommunications Experiment Project 1977/7, Satellite Telecommunication Experiment Project (STEP) with the French-German Symphonie communication satellite.	Experimental 3-axis stabilised communication satellite (APPLE) to be launched in 1981 by the third Ariane vehicle, tested with 2 Earth stations and 3 mobile terminals. Insat system using 2 application satellites mobile terminals. Insat system using 2 application satellites developed by Ford Aerospace and launched by NASA Delta vehicles.

			Insat network consisting of 5 large stations 13 medium stations, 17 mobile terminals. Operational in 1982.
	Earth resources observations	Indian-Soviet satellite for Earth observations, Bhaskara I launched on 7 June 1979 by an Intercosmos rocket: useful data from the microwave radiometer but failure of the 2 TV cameras. Acquisition of a Landsat receiving station, established at Hyderabad.	Second Bhaskara satellite in preparation for for launch from USSR before the end of 1980 - Third Bhaskara planned during 1984. Utilization of the two Insat spacecraft for meteorological pictures and data. Development of Indian remote sensing satellite to be launched from India in mid-80's.
INDONESIA	Domestic communications	Two Hughes communications satellites, respectively launched in July 1976 and in March 1977 and forming the Palapa A system with 40 Earth stations provided by Hughes and Ford Aerospace.	Two enhanced communications satellites developed by Hughes for the Palapa B system planned for 1983 and extended to Philippines, Thailand and Malaysia (ASEAN countries) until 1990.
	Earth resources observations	Acquisition of Landsat data directly from USA (EROS center)	Study of a cooperative project with Netherlands concerning a remote sensing satellite.
IRAN	Domestic communications	Experiments with French-German Symphonie communication satellite.	Prepared before the Iranian revolution, the Zohreh domestic system with 3 satellites......
	Earth resources observations	Establishment near Tehran of a Landsat receiving station (operational?).	Not available.....!
IRAQ	Domestic communications	4 Earth stations using Intelsat spacecraft	Member of the Arabsat system to become operational in the 1980's.
IVORY COAST	Domestic communications	Exchange of TV programmes and educational experiments in TV broadcasts with the French-German Symphonie communication satellite.	Interest for TV broadcasting system by satellite.
KENYA	Earth resources observations	Regional remote sensing centre at Nairobi for image processing, photo reproducing and interpretation training.	Next step will be the acquisition of a Landsat receiving station.
MALAYSIA	Domestic communications	1 transponder lease from Intelsat system - 2 Earth stations.	Participation to the development and utilization of the Indonesian Palapa B system.
NIGER	Domestic communications	User and recent member of the Intelsat system.	4 Earth stations using in 1981 Intelsat spacecraft.
NIGERIA	Domestic communications	3 transponder leases from Intelsat system - 19 Earth stations built by Harris.	Interest for lease of large capacity communications satellite.
OMAN	Domestic communications	1/4 transponder lease from Intelsat system - 6 earth stations.	Member of the Arabsat system to become operational in the 1980's.
PERU	Domestic communications	1/4 transponder lease from Intelsat system - 4 Earth stations.	Development of rural communications by satellite within the regional ASETA system(Andean communication satellites).
PHILIPPINES	Domestic communications	Transponder lease from the Indonesian Palapa A system, with 12 Earth stations built by NEC.	Interested in the acquisition of domestic satellites for TV and communications services (Domsatphil system).
SAUDI ARABIA	Domestic communications	2 1/4 transponder leases from Intelsat system - 15 Earth stations established by Harris.	Major partner in the Arabsat system to become operational during the 80's - Final decision expected during 1981?
SUDAN	Domestic communications	1 transponder lease from Intelsat system - 14 Earth stations.	Member of the Arabsat system to become operational in the 80's.
TUNISIA	Earth resources observations	National remote sensing center at Tunis, using Landsat data.	Next step will be the acquisition of a Landsat receiving station.
UGANDA	Domestic communications	1 transponder lease from Intelsat system - 3 Earth stations	Improvements and extension actually stopped by political events.

UPPER VOLTA	Earth resources observations	Regional remote sensing center at Ouagadougou for image processing, photo reproducing and interpretation training.	Next step will be the acquisition of a Landsat receiving station.
YEMEN (A.R.)	Domestic communications	Transponder lease from Intelsat system - 2 Earth stations.	Member of the Arabsat system to become operational in the 1980's.
ZAIRE	Domestic communications	1 transponder lease from Intelsat system - 13 Earth stations of the Rezatelsat system built by Telspace-Thomsom-CSF.	Interested by the lease of large capacity communications satellite.
	Earth resources observations	National remote sensing centre at Kinshasa. Agreement with NASA for the establishment of a Landsat receiving station.	Construction of the Landsat receiving station depending on the financial status of Zaire.

SOCIETY NEWS

Another BIS Student Success

We are pleased to report that one of our student members, Mr. Jerel Whittingham, was a prize-winner in the 1980 "New Scientist"/British Association: Young Scientists (BAYS) essay competition.

Mr. Whittingham is an 'A' level student taking Physics Maths and Chemistry and the subject of his essay was "Man and Space".

Prize-winners attended the 1980 meeting of the British Association and, in conversaton with other students there, Mr. Whittingham tells us that he was once again struck by the interest aroused by Project Daedalus. "Many had heard of it and were keen to find out more about the ideas behind it even if they had no special interest in spaceflight," he said.

Seven Down, Two to Go.

Many interesting Reports of progress with our new building have appeared in *Spaceflight*, but one item of significance has not yet seen the light of day.

This concerns the near-demise of our Executive Secretary.

The sequence of events began when a temporary electricity supply was installed for the use of the builders in the shell of the new building. It consisted of a large cable leading to a temporary meter mounted on a wooden shelf, on the wall, from which the main was distributed throughout the building.

When the new permanent supply was installed, standard safety practice required that the temporary supply be cut off. This, presumably, had been done, but the large protruding cable with part of the wooden panel still attached was left extending three feet upwards from the floor.

Many requests to the builder to shift this met with no response, with promises not kept, or evasive answers such as "this work has to be done by the Electricity Board". Equally-frequent requests to the Electricity Board also met with the well-known blank response.

Eventually, the time came for the Reception office to be carpeted, but this could not be done with the large cable still protruding from the floor.

By this time the builder had left the site and a final request to return to finish the job brought forth the response, "The cable is dead - why don't you remove it yourself!"

In desperation, our Executive Secretary produced a hacksaw to cut away the offending cable. A few deft strokes showed that a hot water pipe was in the way so he removed the hacksaw and took hold of the wood at the end of the cable to bend it to a more convenient position.

There was a blinding flash. A cloud of black smoke filled the room and there was a smell of burning.

The emergency team from the Electricity Board arrived shortly afterwards and confirmed that the so-called "temporary" supply was very permanent indeed. The Board simply hadn't followed its own safety requirements in cutting off the supply when the new cable was installed. The result was that over 500 volts were still flowing through a "dead" cable - more than enough to kill anyone who touched it, and certainly lethal to anyone hacksaw in hand.

L.J. Carter, Executive Secretary, British Interplanetary Society.

The crew of five who turned up with a large lorry took two days to dispose of the lethal supply, which involved digging up part of the road and part of the pathway.

Our Executive Secretary had missed death by a fraction of a millimetre.

His only comment seemed to add this to other "near-misses" in his reputed nine lives.

All he said was "Seven down - two to go!" Eric Waine. ●

FURTHER THOUGHTS ON INTERSTELLAR EXPLORATION

By James Strong

Introduction

Today's continuing interest in the proposed exploration of nearby stars with the aid of Daedalus-type space-probes deserves to be encouraged. With a view to deciding whether there was an optimum pattern for stellar exploration I ventured a first tentative look at the disposition of the local stellar population some ten years ago [1]. More recently, A. W. Orme has put the subject into perspective by developing the theme rigorously and, at the same time, adding depth to it [2]. But in my view much remains to be done, up-dating our knowledge systematically until it is encyclopaedic in every respect.

Meanwhile, the intervening years have witnessed the evolution of Project Daedalus, an interstellar probe based on a mode of propulsion which is fundamentally sound [3]. Manned starflight, using a similar mode, will follow in time but take longer to develop, for the starship which ultimately emerges will call for the expenditure of power on a truly prodigious scale. It must generate this power if it is to traverse the gulfs between the stars in less than a lifetime.

However, before we are bedazzled at the prospect of stellar exploration, some pertinent questions need to be answered. For instance, precisely what do we imply by the term "exploration"? Do we intend exploring at first hand, in person, or are we going to rely entirely on our autonomous star-probes to do it for us? Maybe we are saying one thing, and perhaps dreaming about something entirely different and, I am afraid, impracticable? In fact, are we talking of "emigration" rather than "exploration"?

Possibly some will feel such questions are irrelevant. But I am mindful of something I wrote long ago, that . . . 'Historical precedents for territorial expansion on Earth *do not apply to expansion among the stars*' [4]. Nothing has happened since to make me change that view, but we may be in danger of forgetting the reasons behind the statement. Perhaps it would be beneficial if we took a closer look at the basic problem of interstellar travel. We may find there are some surprises.

The Speed Problem

First of all, let us try to be rational when entertaining thoughts of starflight. In Project Daedalus we have a system of propulsion which, though founded on theory and still unproven, is nevertheless basically sound in principle. Of course there are problems to be solved, a veritable host of them, but they are all capable of solution, if not in one way then by another. We have nothing else to match its potential, so let's stick with it. Black Holes and 'Warp Factors' as a means of transporting the starry-eyed from one part of the Galaxy to another are no better than the Fourth Dimension and F.T.L. (faster than light) clichés used by a previous generation.

At present the top speed predicted for the Daedalus 2nd Stage is estimated to be 12½ percent of the speed of light. But once a prototype propulsion unit were to be built and put together in orbit, even if it reached only 0.1% of the speed of light, it would be a triumph. It would still be ten times faster than anything launched into space so far. From then on development cannot fail to improve its performance, as in every other form of engine ever produced. And once we can bolster theoretical performance estimates with real data, we can begin to predict the future.

All the same, from this beginning can we justify claiming that 12½ 'psol' is capable of being doubled by subsequent development. I think it is, and that speeds in the region of 25-33% of the speed of light will eventually be realised. Perhaps these are not the dizzy heights to which some have hoped to aspire, but they are certainly better than nothing. In private I may add that figures far in excess of these have been confided to me as being feasible. However, when we come to consider the engineering aspects of a manned starship, such as size, gross weight, on-board power requirements, efficiency of fuel-conversion, etc. I think we shall find there are many factors which militate against any higher speed.

Even so, with this measuring rod of performance at our disposal, the trip to *Alpha Centauri*, our nearest star, will still take between 16-21 years, allowing 3 years at each end for constant acceleration and deceleration. Let me hasten to add, of course, that this assumes that a planet of reasonable habitability awaits us at the end of the journey, for if not we must look elsewhere for our first sortie into galactic space. Nevertheless, the thought which does spring to mind is - who would willingly spend 16-21 years cooped up in a starship? Stellar exploration bears a little hard on mental stamina if this is the best we can do.

So far, so good, the optimists may be tempted to say. But travelling to the nearest star has little relevance to the general problem of interstellar exploration. Beyond *Alpha Centauri*, the next star in that direction of any significance, *Delta Pavonis*, is another 14.3 light-years further on, or 18.6 light-years direct from the Sun. So if there is no planet around the twin suns of *Alpha Centauri* (which is quite probable seeing as it is a binary), then we are, so to speak, back to Square One.

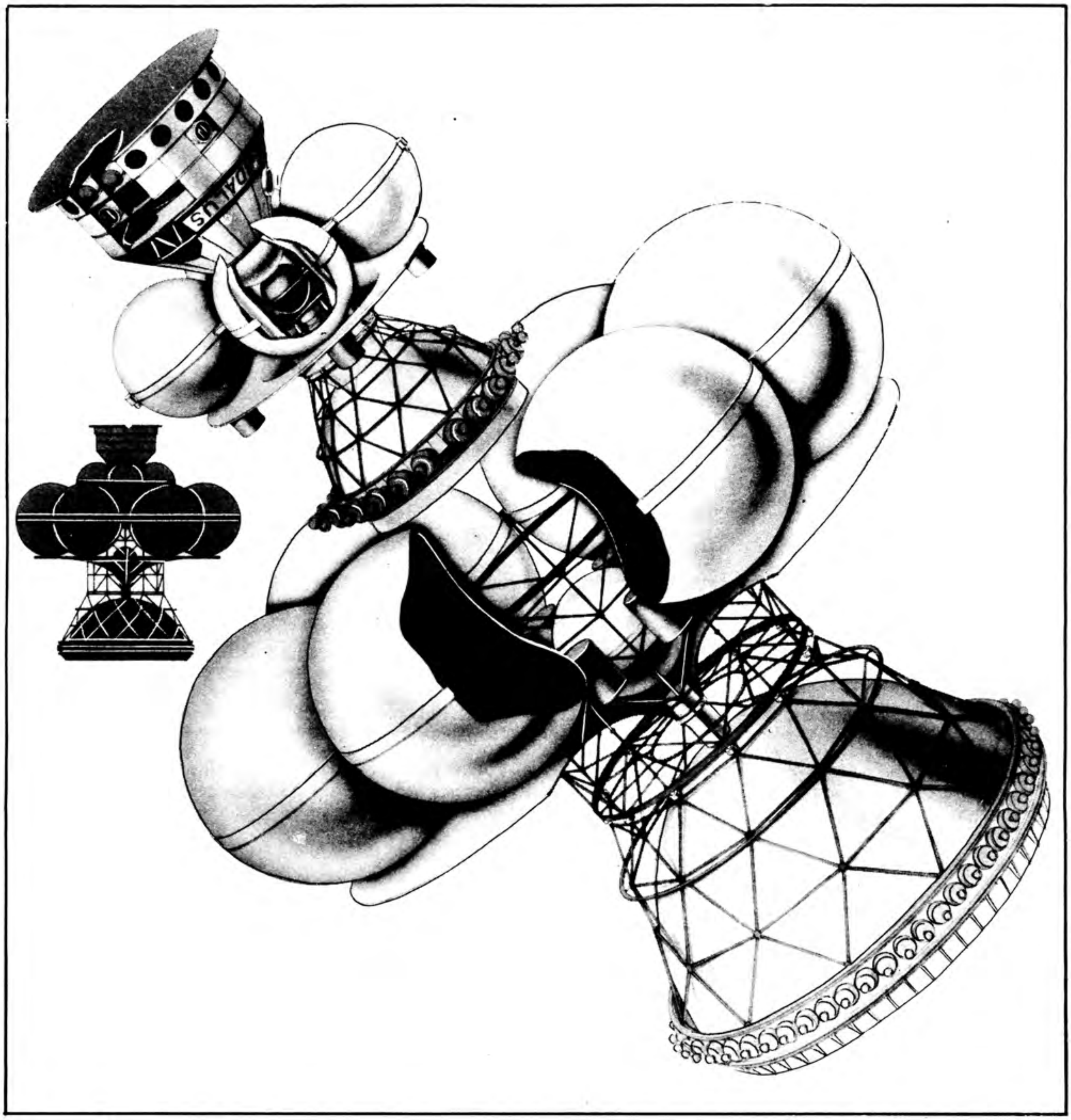
Hence, if our programme of stellar exploration is to be one of steady and continuous expansion, we must strive to be knowledgeable about all stars and accompanying planetary systems in our neighbourhood. A spherical radius of 5-6 parsecs should be quite sufficient for our immediate purpose.

The Distance Problem

To begin, the average separation of all stars in the vicinity of the Solar System is about 7½ light-years. Sometimes it is less, but 7-7½ is a good all-round figure, though it must be remembered that two-thirds of all these stars are red dwarfs. If we count only stars similar to the Sun, such as G-type and early K-type, the average separation is more like 11-15 light-years. Moreover, in order to reach these stars, mission times are likely to be as long as 40-50 years!

A point that scarcely needs to be emphasized is that only G-type or early K-type stars are likely to have planets suitable for humans to inhabit. On the other hand, there is a lot of evidence to suggest there are large, super-planets around some red dwarfs. However, for a world circling a red dwarf to enjoy an environment comparable to that of the Earth, it needs to orbit so close to the primary that almost certainly its rotation will have largely ceased through tidal action, like that of the planets Venus and Mercury. The chances are, therefore, that if there are any Earth-size worlds, they will be far from the star and about as warm as a ball of methane. Whilst every expedition to the stars is expected to be self-sufficient if it can draw energy from a star, there are limits to its chances of survival that should not be ignored.

It follows that a compendium of the entire red dwarf population, together with their planetary systems, if any, must rank high on the list of interstellar priorities. We are thinking now more of their use in an emergency, rather than as temporary stepping-stones to other stars. One can imagine that in an emergency a "slingshot manoeuvre" around a large planet might be the means whereby the crew could return homewards, whereas a "cometary orbit" around a red dwarf might be a trifle risky. There is also undoubted psychological stimulus to be drawn if, halfway through a long voyage, a minor detour enables the crew to witness another planetary system, though of course there can be no question of stopping because of the fuel problem.



Daedalus starship concept (BIS). Illustration is taken from colour artwork prepared for the new "Illustrated Encyclopedia of Space Technology" by kind permission of the publisher Salamander Books Limited, London.

The Time Problem

Suppose now we indulge in a 'quantum jump' into the future. In other words, let us imagine that having overcome every difficulty we have reached a hospitable planet around, shall we say, a G-type star. As we took some 40 years to get there, the original crew are by now somewhat long in the tooth; some have died, we suspect of boredom, and a few are quite senile. All thoughts of returning home went by the board long ago, and though communication with Earth continues on a reciprocal basis, all sense of reality is lost when news bulletins are 12 years out-of-date. This may be stellar exploration, but the expedition has clearly reached a crisis.

At this juncture there is only one option. If the technology of the planet's present occupants is sufficiently advanced to take advantage of the benefits the newcomers can bring, then further exploration may soon proceed with a younger crew. But if the technology is simply not there, nothing at all can be done. Our own technology, as we well know, was acquired largely during the last 100 years, whereas the preceeding millenia, counting back to the Ice Age, were a dead loss. Hence the odds against finding an advanced culture are formidable, and a knowledge of high-energy physics and spaceflight are of no use to a culture that has not yet invented the wheel.

There is of course nothing to prevent a second expedition following on the heels of the first, but if the circumstances are the same its fate will be no different unless it can travel faster and carry more fuel. But so far as terrestrial expansion into the Galaxy is concerned, exploration looks like stopping right here, leaving the original crew to be absorbed into the mythology of the existing race.

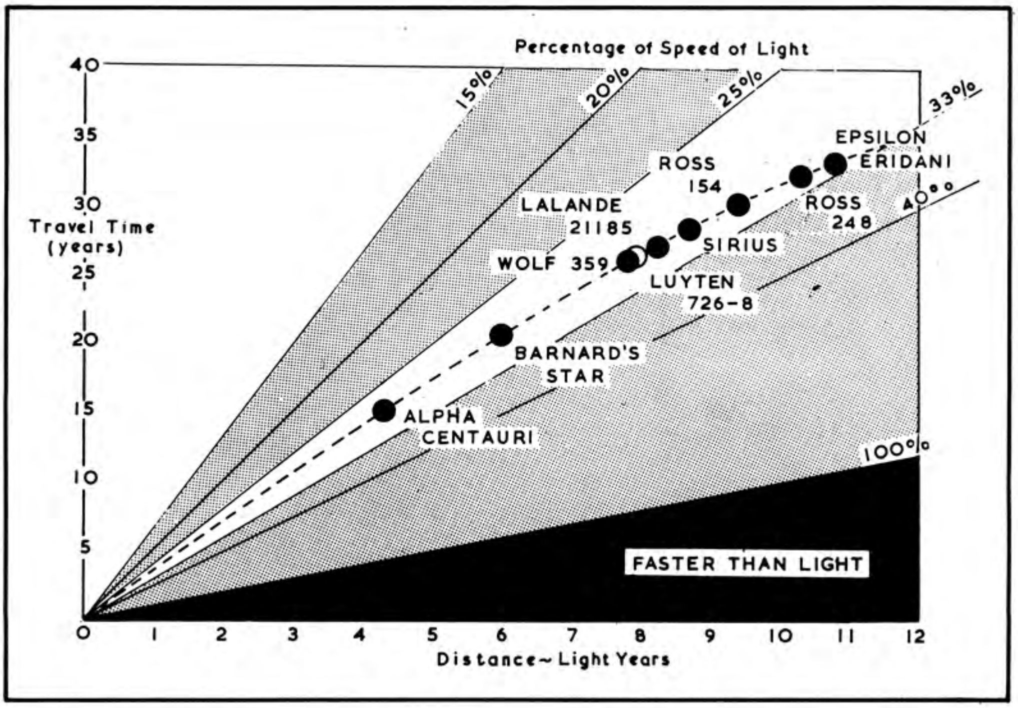


Fig. 1. A Speed-Time-Distance curve for the nearer stars. Travel times only become reasonable when speeds reach 25 to 33 per cent of the speed of light.
Copyright James Strong

Discouraging though this may seem it is by no means the end of the story. From Earth other, manned expeditions will sally forth towards prospective stars where star-probes have shown there are habitable worlds. Such sorties may number no more than half-a-dozen at most. For there will be a limit beyond which further attempts will be impossible, either because of the distance involved, the exhaustion of Earth resources — especially that of fuel — or the will to reach the stars has faded. With only one successful attempt Man will have demonstrated that he can perpetuate his species, and obey the pattern Nature intended.

So, in the end, each expedition that succeeds achieves its own small goal of exploration, only to be swallowed up in the legends of the world it came to explore. And in doing so it raises a question of considerable interest: "How long will it be before technology on the new world rises once again, like a phoenix, to a level that permits the inhabitants to launch a fresh mission to the stars?" I believe it is a time not far short of 10,000 years.

Let us suppose, therefore, that sometime in the next century we launch an expedition ourselves. Does it mean that 10,000 years hence, on a world around some unknown star, distant relations of ours will be casting round to see if there are feasible opportunities for stellar exploration? They will have long forgotten their ancestors came from Earth, but they will notice a G-type star not too far away, one that their scientists reluctantly admit might be suitable if it had a habitable planet, which of course they doubt. Undeterred they will begin to prepare for the mission. Is it conceivable that the descendants of those we send out from Earth 100 years from now *will come back again ten millenia later*?

In 10,000 years time the heavens will still look much the same; there will be differences of course, and a few stellar positions will change dramatically. *Alpha Centauri*, for instance, will be ¾ light-year closer. *Delta Pavonis*, too, will be closer by roughly the same amount. *Tau Ceti* will have moved ½ light-year nearer, but *Epsilon Eridani* will draw away slightly.

Unfortunately, many of the most promising stars in our neighbourhood are moving steadily away from us, and the list includes *Beta Hydri*, *Sigma Draconis* and *82 Eridani*, all G-type stars. In fact, except for *Alpha Centauri*, golden opportunities for stellar exploration are rapidly dwindling. Even the red dwarf population seems to be shunning us, apart from Bernard's Star, which will be less than 4 light-years away 10,000 years from now. All in all, this is not an auspicious moment to go exploring.

The Theory of Continuous Opportunity

But if our theme of interstellar exploration is disappearing, temporarily at least, in its place a philosophy quite different seems to be emerging. In a manner of speaking it is reminiscent of Fred Hoyle's "Theory of Continuous Creation", except that for 'continuous creation' we should read 'continuous opportunities for interstellar migration'. In effect it is a theory which postulates that there are as many random options open to us to emigrate today as there were in the past, or will be in the millenia ahead. It follows that, when the time is ripe and the means for interstellar travel come to hand, men will emigrate to the stars in small numbers, *but the tickets will all be one-way*.

It means that if distances of 11-15 light-years are covered every 10,000 years, the next 100,000 years will see at best a total radial movement of 110-150 light-years. Moreover there is plainly a 50-50 chance that some of the steps will be in the reverse direction, so that the net displacement could be halved, or even zero. Like the Black Queen in "Alice through the Looking-Glass", we may have to run like hell just to stay in the same spiral arm. At this rate goodness knows when we can expect to say we have explored the Galaxy.

But though I have implied that all our efforts to explore the more distant stars will come to naught, there is a way round the dilemma, though most of us are likely to find it too grim to be acceptable. However, if we really insist that mankind should attempt to explore the Galaxy it can only be via the mindless, aimless wanderings of a gigantic "generation-type" starship. Such a vehicle would need to be of enormous size for it must be capable of reproducing itself, as parts wear out, as well as its crew.

What Is To Be Gained?

We may well ask, what will mankind gain from such a vehicle? Only knowledge of far-off places is the answer, knowledge that may be studied during the long years between the stars, knowledge that could be relayed back to Earth where it might be of passing interest, for how long? Inevitably such a vessel will one day cease to voyage, coming finally to rest, for what

reason who can tell. Maybe its crew will be insane.

To the stars we must go some day, but stellar exploration, I believe, is a misnomer; at heart it is an exercise in survival. For the chosen few the starship is a means to an end, minimising the risk of extinction of the human species by spreading its seed as widely as possible. Some of those seeds will survive, and some will fall on no ground at all. Stellar exploration is not for the masses, at least not in this patch of the sky. But do not let us stop dreaming about it, for I am quite sure it is dreams that make things come true.

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3. *Project Daedalus*, The Final Report of the BIS Starship Study, British Interplanetary Society, London, 1978.
4. J. Strong, *Flight to the Stars*, Hart Publishing Co. Inc., New York.

ASTRONOMICAL NOTEBOOK

By J.S. Griffith, Lakehead University, Thunder Bay, Ontario, Canada.

SOLAR SYSTEM

The dynamical interaction of a high-speed solar-wind stream with a comet is considered. The evolution of the comet Kohoutek's side rays and the disconnection of its ion tail are explained by the model.

The interaction of the solar wind with comets consists of three major parts. Mass loading of the cometary ions leads to a bow shock upstream of the cometary head: compression of the interplanetary magnetic fields takes place into a magnetosheath just above the contact surface (ionopause) of the comet; convection of the draped interplanetary magnetic-flux tubes downstream leads to an ion tail with tail-aligned magnetic field. Similar interactions take place in the case of Venus, where observations have shown formation of a magnetosheath just above the ionoshpere with ionoshperic pressure approximately equal to the magnetic pressure at the boundary and the position of the ionoshpere having a large time-variation dependent on the solar-wind conditions. In ref. [1] the Venerian conditions are applied by analogy to the comet-solar-wind situation and in particular one ion-tail disturbance of comet Kohoutek is examined as an example of the dynamical response of a comet to a solar-wind disturbance.

Between 19 and 21 Jan 1974, there was a sequence of changes in the ion tail of comet Kohoutek (1973 f). A large disturbance in the ion tail with the appearance of a joint was followed by the formation of a system of raylike filaments along one side of the tail. Finally the main ion tail became disconnected from the head. The whole ion-tail disturbance may have been related to the entry of the comet into the compression region of a high-speed stream. At the peak of the compression region of the stream, the positions of the shock and contact surfaces of the cometary ionosphere are greatly reduced, leading to loss of a large proportion of plasma in the original ion tail. The six-fold increase in pressure of the solar-wind plasma may overcome the pressure of the cometary ionosphere, uprooting the whole ion tail from the head.

[1] Ip, W.-H., 1980, On the dynamical response of a cometary ion tail to a solar-wind event, *Astrophy J.* **238**, 388-393.

Variable G and the Solar Luminosity

Variations of the gravitational constant G with cosmological time have been discussed for about 40 years. One reason for rejection of any variation has been its possible effect on the luminosity of the Sun. This effect is reanalysed and shown not to exist.

In 1937 Dirac (ref. [2] suggested that G may have been different in the distant past. Calculations (ref. [3]) appeared to indicate that the solar luminosity would be drastically affected, and the deduction made that G had been constant. In ref. [1] the matter is reinvestigated.

It is found that GM = constant, so that using planetary dynamics where G only enters via Kepler's law in the form $w^2R^3 = GM$ and is always multiplied by M, we cannot expect to deduce any information about a variable G. It is also found that the solar luminosity is constant in time.

[1] Canuto, V. and Hsieh, S.-H., "Cosmological variation of G and the Solar Luminosity," *Astrophy J.*, **237**, 613-615, 1980.

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[3] Teller, E., *Phys. Rev.*, **73**, 801, 1948.

GLOBULAR CLUSTERS

Globular Clusters near the Galactic Centre

The globular clusters within 6 of the galactic centres were investigated. Their distribution and composition give clues to understanding the dynamics and chemical evolution of the Galaxy. Because of the large interstellar extinction, optical observations are severely limited, so infrared photometry and raster maps were used.

The three objects investigated in ref. [1] are Terzan 2, Liller 1 and UKS 1751-241. The authors used the Mount Hopkins Observatory 1.5 m telescope and an InSb detector cooled to 55K to obtain infrared photometry and raster maps, using the technique described in ref. [2]. The observations and their subsequent analysis confirms that all three objects are globular clusters with core radii from 7 to 13 arc sec. Terzan 2 is from 14 to 24 kpc away, and UKS 1751-241 is probably near the galactic centre, about 10 kpc from the Sun. Unlike Liller 1, UKS 1751-241 does not appear to have any X-ray emission, though it is a concentrated, highly reddened globular cluster.

The core relaxation times, core mass, central density and total mass are also derived.

[1] Malkan, M., Kleinmann, D. E. and Apt, J., "Infrared Studies of Globular Clusters Near the Galactic Centre", *Astrophy J.*, **237**, 432-437, 1980.

[2] Apt, J. and Goady, R., *J. Geophys.* Res., **84**, 2529, 1979.

GALAXIES AND QUASARS

Hi Envelope around a galaxy

The Type 2 Seyfert galaxy Mrk 348 has been found to have an HI envelope about ten times larger than the galaxy itself.

Using the 305 m. Arecibo radio telescope the authors of ref. [1] mapped an extremely large hydrogen cloud around Markarian 348. It has been suggested [2] that the absorption-line systems in QSO spectra can be explained if there are "huge galactic halos which contain heavy elements and even larger

regions which are composed of hydrogen alone", so these observations which suggest the extended envelope of Mrk 348 is composed of primordial material need to be augmented by an investigation of the evolution of giant HI envelopes. Rather than being a young galaxy, it is suggested that conversion of gas into stars is proceeding at a slower rate in Mrk 348 than in the majority of galaxies.

In ref. [3] the optical properties of Mrk 348 are discussed, and it is found that even if the large mass of HI is feeding the central nuclear source, that source will not affect the dynamics of the HI envelope on the time scales normally associated with Seyfert galaxy evolution.

[1] Morris, M. and Wannier, P.G. (1980), "An enormous HI envelope around a Seyfert Galaxy", Astrophy J., Letters, **238**, L7 - L 10.
[2] Berbidge, G., O'Dell, S.L., Roberts, D.H. and Smith, H.E., 1977, Astrophy. J., **218**, 33.
[3] Huchra, J., 1980, "The Optical Properties of the Unusual Galaxy Markarian, 238", Astrophys. J., Letters **238**, L 11 - L 12.

Galactic Flares?

The effect of the differential rotation of the disk of the Galaxy on the magnetic field which penetrates the disk leads to instability. Using an analogy with solar flares, an MHD instability, perhaps combined with a resistive instability, leads to release of the excess magnetic energy, some of which is converted into heat. Estimates of the parameters of the resulting plasma are made, and it is found that this process can heat a galactic corona to temperatures of the order of 10^6 K.

An explanation of the diffuse soft X-ray (E less than 1 KeV) background is the presence of a coronal-type plasma of temperature around 10^6 K (ref. [1]). If the corona is heated by supernovae, it will extend at least several kiloparsecs above the plane of the Galaxy. For the Sun, we know that energy is released impulsively at coronal heights during flares. The energy released during a flare is probably stored above the photosphere in the form of the free energy of a current-carrying magnetic field. Differential photospheric motion interacting with magnetic flux threading the photosphere leads to non-potential field configurations and hence to free magnetic energy. Knowing the disk of the galaxy is in a state of differential station and assuming that magnetic fields thread the disk of the galaxy, extending out to a galactic corona, we see the same ingredients in the galaxy as lead to flare activity in the Sun. The proposal that galactic flares provide a substantial energy input to the interstellar medium, heating the coronal plasma responsible for the diffuse soft X-ray background, is investigated in ref. [2].

It is known that the plasma responsible for the soft X-ray background probably has a complex thermal structure. This form of structure is predicted by the model, which gives approximate order-of-magnitude agreement with observational data. Some of the high velocity clouds of neutral hydrogen outside the galactic plane may be the galactic analogs of "coronal rain" which often occurs in the loop prominence systems formed by some large solar flares as a result of the thermal instabilities in the hot dense plasma in the coronal volume of an active region. The energy radiated by the galactic corona is less than one-tenth of the rotational energy of the gas in the galactic disk.

[1] Tanaka, Y., and Bleeker, J.A.M., 1977, *Space Sci. Rev.*, **20**, 815.
[2] Sturrock, P.A. and Stern, R., 1980, "Is the Galactic Corona Produced by Galactic Flares?", Astrophys. J., **238**, 98-102.

The Double QSO 0957+561

The two quasars considered have similar red shifts, column density of Fe^+ and velocity dispersions. The simplest interpretation is of a very massive object gravitationally deflecting the light from a more distant QSO. The object would need to be very massive (10^{14} solar masses at $z = 1.2$) or have a very large mass-to-light ratio if it is closer than $Z = 0.4$. The alternative is two massive QSO's actually closer than they appear to be by mutual gravitational deflection of their light.

The two QSO images were discovered in 1979 [2]) to be separated by only 6". The small differences in spectra could be explained by differential extinction perhaps near the QSO or in the halo of an intervening galaxy acting as a gravitational lens. Using the UVITS spectrograph and intensified dissector scanner (IDS) at the f/9 Cassegrain focus of the McDonald Observatory 2.7 m reflector (ref. [3]) observations were made on 23, 24 and 27 May, 1979.

With the assumption that the two objects are gravitational lens images of one QSO at a cosmological distance, it is found that the small differences in spectra are probably due to an absorbing medium similar to the local interstellar medium at a red shift near 1.2. Both reddening and absorption seem to occur in the same material. The absorber is close to the QSO. The object that may be the lens if no brighter than 23 magnitudes, so with a high red shift the derived mass is very large (greater than 10^{14} solar masses). For a close gravitational lens the mass is even higher. The existence of two separate QSO's is still an attractive alternative - like a galaxy with a double nucleus. For a distributed (galaxy) mass rather than a point mass we do not need the lens galaxy to be near the midpoint of the QSO images (ref. [4]).

There is a faint image about 1 north of one of the QSO's, which is probably the lens galaxy. The data fit an E SO galaxy at a red shift of about 0.375. This hypothesis leads to a better agreement between the two quasar spectra.

[1] Wills, B.J. and Wills, D., 1980, "Spectrophotometry of the Double QSO, 0957+561", *Astrophys. J.*, **238**, 1-9.
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[3] Rybski, P.M., Mitchell, A.L., and Montemayor, T., 1977, *Pub. Ast. Soc. Pac.*, **89**, 621.
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Continued on page 145

Space in the European Parliament

Seldom reported in the daily press or on radio or television are the debates of the European Parliament which affect science and technology. Indeed, it may come as something of a surprise to find that some of the most perceptive questions coming from the floor, or in the form of written submissions, concern European interests in space.

Lord Bessborough got matters off to a good start as long ago as June 1975 when he asked:

'What measures is the Commission taking to encourage the exploitation of the new methods of remote sensing from aircraft and satellites for the survey of natural resources, particularly for overseas development, and for the monitoring of the European environment and the neighbouring areas?'

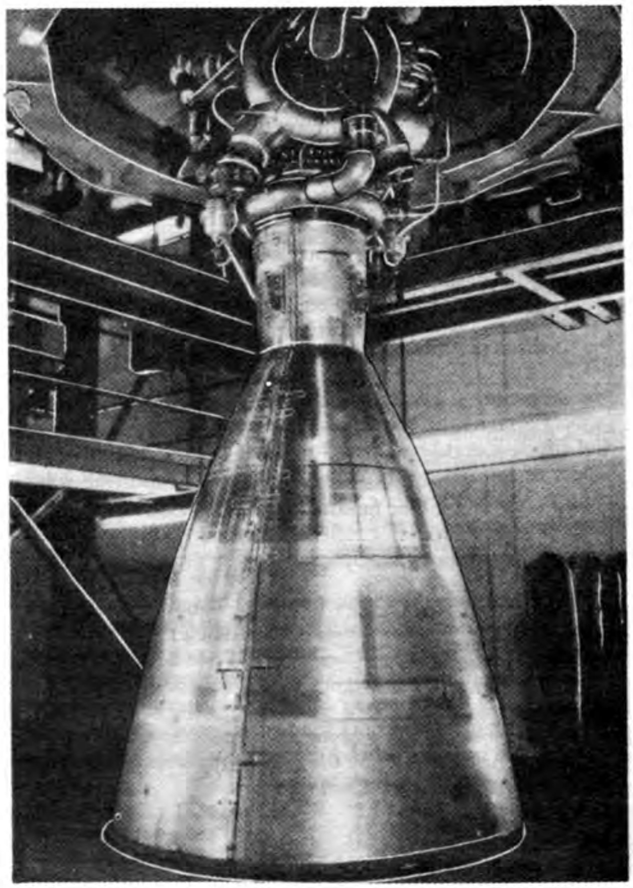
Lord Christopher Soames, then Vice-President of the Commission, replied that the Commission was actively considering the areas in which remote sensing is of practical utility in relation to the Communities' policies.

It was working closely with the European Space Agency in studying the backup facilities which were needed as the opportunities offered by remote sensing were exploited and ways were found of improving the distribution of data and pictures transmitted by satellite.

The opportunities for remote sensing in the European context were further discussed on this and other occasions which served to emphasise ways in which ESA and its research centres might assist.

It will not surprise members to know that the B.I.S. is often consulted on matters of scientific and technical policy related to space affairs by members of the European Parliament who are thereby enabled to bring the most informed opinions to bear. A recent example was a consultative document on the subject of micro-gravity processing of semi-conductor materials in the space environment and the impact this might have on future development within the European electronics industries.

One of the key benefits of the exchange of view with our European partners and one the Society never ceases to emphasise - is the political strength that it gives to the European Space Agency (ESA) whose achievements are so often under-reported. In the interests of developing this organisation, it is vital that the message is aired repeatedly within the European Parliament (and our own Parliament for that matter) that Space is here to stay and European industry can only benefit from a close association with space science and technology.



Europe's growing influence on space markets is well illustrated by work on the Ariane launcher. Here the second stage engine for the 03 vehicle to be launched this summer is seen at the ERNO plant in Bremen.

ERNO

We are therefore pleased to see that some of the issues raised during the past 18 months have been directed at realistic issues affecting the application of space techniques in Europe. The quality of debate has been high.

Below we give a few examples of questions and answers:

March 10 1980

Question No 24 by Mr. Seligman (H-482/79):

What are the institutional problems inhibiting involvement in encouragement and participation of the Community in the work of the European Space Agency?

Mr Cheysson, *Member of the Commission.* – The Commission considers that the differences in legal basis between the European Space Agency and the Community do not at the moment cause any real problems between these two institutions, witness the joint projects that have already been undertaken, particularly in the telecommunications field, namely the Stella and Spine pilot experiments, remote observaton of the Earth, provision of data for the CCR programme via the Earthnet network, the proposals for joint CCR/ESA experiments using Canadian equipment and data banks, and the incorporation of the Information Retrieval System of the Space Agency's space documentation centre in the Euronet-Diane network.

On top of these concrete actions there is the continuous consultation as regards industrial policy and external markets.

ASTRONOMICAL NOTEBOOK

Continued from previous page

Faint Blue Objects

The nature and clustering properties of blue objects (B W 23) in a field at the south galactic pole are investigated. These compact blue objects are classified as quasars, and their lack of clustering leads to implications about theories of quasar evolution.

Using plates taken by the UK 1.2 m Schmidt telescope in Australia, several thousand blue and red images of objects in a field at the south galactic pole were investigated (ref. [1]) with the aid of the COSMOS measuring machine at the Royal Observatory, Edinburgh (ref. [2]). The faint blue objects were of two types. The diffuse clustered images were classified as distant spiral and irregular galaxies with a comparison sample of very red images being redshifted elliptical galaxies. Down to a magnitude of B = 22 the relative clustering properties of the spiral and elliptical galaxies displayed no significant difference from those for brighter objects. The compact blue objects were not clustered significantly and are classified as quasars. Models of evolution associating all giant elliptical galaxies with quasars at an early epoch are not consistent with the observations.

[1] Hawkins, M.R.S., "On the Nature and Distribution of Faint Blue Objects", Astrophys. J., **237**, 371-377, 1980.

[2] Pratt, N.M., "Vistas in Astronomy," **21**, 1, 1977. ●

Lastly, the Commission and the European Space Agency are actively cooperating in formulating a tele-data action programme following the Commission's submission of a report to the European Council in Dublin on European society and the challenge of the new information technologies. This programme is a definite Community response. The cooperation in question covers the use of satellites, the harmonization of protocols and standards for the interface between satellites and Earth-station equipment.

The Commission would point out that it is pursuing its cooperation with the Space Agency in the spirit of the resolution adopted by this Parliament on 25 April 1979 on the basis of Mr Ripamonti's motion for a resolution. It intends, whenever the situation permits, to strengthen its links with the Agency.

Mr Seligman. – I very much welcome the Commissioner's reply. Certainly the cooperation seems to be much more close and effective that I had thought. I would like to add one other aspect of satellite work, namely, the area of capturing solar energy, which is another field of the future. Anyhow I hope that the Commission will continue to play a very official and active part in the European Space Agency.

Mr Cheysson. – I shall report to Mr Davignon and we shall inform our services of the suggestion made by the honourable Member. On behalf of the Commission I can assure him that we attach the utmost importance to our cooperation with the Space Agency for the sake of that cooperation itself and also because it signposts a series of industrial policies which, in our view, should be dealt with by the nine governments on a joint basis and developed by the Community.

September 15 1980

President. – Question No 15 by Mr Seligmann (H-260/80):

What steps is the Commission taking to ensure that Member States are linked into the French and German national programmes for direct broadcasting spacecraft and the L-SAT programme of the European Space Agency, so that European space interests are not divided on the world scene and in the world market?

Mr. Davignon, *Member of the Commission.* – I should like to make three remarks. Firstly, we must be clear on one point: the convention setting up the space agency stipulated that the text applied to cooperation between European countries. Therefore the Community has no powers in the space sector. This section was obviously not included in the Treaty of Rome because at the time when the Treaty was drafted, activities of this kind did not exist. Subsequently the countries created a structure outside the European Community, probably in order to cover a larger number of states because at the time the Community only had six members. That is a fact which must be borne in mind.

My second point is this: the relationship which exists between space activities and industrial cooperation is clearly such that the Community, and in particular the Commission, is responsible for ensuring firstly that the resources of the Community are utilized to the best possible effect and secondly that the Community is not placed at a disadvantage in terms of technology, the marketing of technologies and competition at world level. That is why the Commission has devoted a substantial part of its document on technologies of the future to this particular subject.

That brings me to my third and last remark: we are at present in what may be described as a pre-operational situation. The projects which now exist do not yet have any immediate and direct commercial spin-off. The countries which are developing these projects, either the space project or the bilateral Franco-German project, are doing so to gain a mastery over the relevant technologies and not yet to implement those technologies. But when we do reach the stage of implementation, a whole range of juridical and technical problems will arise and here standardization at European level will obviously be of interest. It will be essential if we want a sufficient market to exist for these technologies; we shall have to start with a domestic market in order to be in a position to propose these technologies to other countries later on.

Mr Seligman. – I thank the Commissioner for that very interesting reply. He says that the Community has no power to intervene in space matters. But if a satellite is used for TV broadcasts it will be handling cultural and advertising material, thereby making it a commercial matter. I think it is most important that the Community should get involved as soon as possible. Would it not be possible for the German and French satellites to be beamed to the rest of the Community so that we can share the cultural value of these broadcasts? If not, can we have a start on a Community satellite to provide European coverage for this sort of cultural and commercial material?

Mr Davignon. – It is not possible to give specific answers to that question because the possible coverage of broadcasts of this kind depend on the technology which is used. Of course that is not the fundamental point made in Mr Seligman's question. He is interested rather in knowing whether we consider it necessary to conduct a series of exploratory conversations with industrialists and national authorities to prepare ourselves for a situation which will arise in the future. I can confirm to the honourable Member that this is what we are trying to do from the industrial angle, i.e. from the angle of the creation of an adequate basic industrial infrastructure and from that of further infrastructures at user level: all this is very important if we are to gain full control over these technologies. Secondly, we are surveying all the problems which will arise once the new technologies are brought into use so as to obtain, for both juridical and cultural reasons, a clearly defined situation within the Community and so as to be able to put forward ideas for further consideration by the interested parties - it is our intention to work on those lines.

September 17 1980

President. – I call Question No 68, by Mr Seligman (H-272/80)

What steps has the Council taken to ensure political benefits of closer contact between Arab and European peoples through involvement of Community firms and Community finance in the implementation of the Arab Telecommunication Satellite Project, now that the Arab Satellite Communications Organization is issuing a new tender later this year?

Mr Thorn, *President-in-Office of the Council.* – The Council recognizes in general terms the advantage of participation by the Community and its Member States in the implementation of regional projects such as the one referred to by the honourable Member, as this could only strengthen cooperation links between Europe and the Arab world. However, no proposal concerning the project in question has been placed before the Council.

Mr Seligman. – Does the President-in-Office not agree that better relations between the EEC and Arab peoples would benefit both sides not only in the supply and price of oil, but should also benefit general commercial and cultural relations, including especially giving the Community's space technology firms a stronger competitive position?

Other powerful nations, such as the USA and Japan, do not necessarily distinguish between their political and their commercial interests and they often give substantial financial assistance to their exporters. Why should the EEC Council not give a lead in the same way by giving some sort of assistance to our space technology firms in this matter? I think they should not wait to be pressed on this by certain special interests.

Concluded on page 156

SATELLITE DIGEST — 146

A monthly listing of all known artificial satellites and spacecraft. A detailed explanation of the information presented can be found in the January 1979 issue, p. 32.

Robert D Christy

Continued from April issue

Name, designation and object number	Launch date lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclination (deg)	Nodal period (min)	Launch site launch vehicle and payload/launch origin
Intelsat 5A (F2) 1980-98A 12089	1980 Dec 6.980 indefinite	Box+2 panels 1065		35638	35734	0.86	1430.87	ESMR Atlas Centaur Intelsat/NASA (1)
Cosmos 1226 1980-99A 12091	1980 Dec 10.87 1000 years	Cylinder? 700?	2 long? 2 dia?	964	1012	82.94	104.95	Plesetsk C-1 USSR/USSR (2)
1980-100A	1980 Dec 13							DoD/USAF (3)
Cosmos 1227 1980-101A 12100	1980 Dec 16.51 12 days (R) 1980 Dec 28	Cylinder+sphere +cylinder-cone? 6000?	6 long? 2.4 dia?	228 224 227	299 284 306	72.84 72.84 72.84	89.82 89.63 89.88	Plesetsk A-2 USSR/USSR (4)
Cosmos 1228-1235 1980-102A-H 12107, 12109, 12110, 12113, 12111, 12114, 12108, 12112	1980 Dec 23.95 9000 years	Spheroids? 40?	1.0 long? 0.8 dia?	1395 1401 1408 1411 1415 1416 1416 1420	1465 1464 1464 1464 1464 1464 1464 1465	74.00 74.00 74.00 74.00 74.00 74.00 74.00 74.00	114.48 114.55 114.62 114.66 114.70 114.71 114.72 114.76	Plesetsk C-1 USSR/USSR (5)
Prognoz 8 1980-103A 12116	1980 Dec 25.17 12 years?	Spheroid+4 vanes 950?	1.8 dia?	979	197369	65.83	5688	Tyuratam A-2-e USSR/USSR (6)
Ekran 6 1980-104A 12120	1980 Dec 26.49 indefinite	Cylinder+2 panels +antenna array 2000?	5 long? 2 dia?	35737	35832	0.06	1435.87	Tyuratam D-1-E USSR/USSR (7)
Cosmos 1236 1980-105A 12121	1980 Dec 26.67	Cylinder+sphere +cylinder-cone? 6000?	6 long? 2.4 dia?	170	364	67.13	89.88	Plesetsk A-2 USSR/USSR (8)

Supplementary notes:

(1) First launch of the latest generation of Intelsats, capable of carrying 12000 simultaneous telephone calls together with two television channels. Intelsat 5 is three-axis stabilised using control thrusters; earlier satellite types were spin stabilised with despun antennae. It is stationed above the Atlantic Ocean.

(2) Navigation satellite.

(3) US military launch — no details available.

(4) Orbital data are at 1980 Dec 17.1, Dec 21.0, Dec 21.1.

(5) Multiple launch of eight satellites, possibly for military communications. An orbit is shown for each satellite.

(6) High altitude magnetospheric observatory.

(7) Domestic television relay satellite broadcasting to small receiving stations in remote communities. The satellite is stationed above 99 degrees east longitude.

(8) Long-life recoverable reconnaissance satellite.

Amendments:

1980-79A, Progress 11 undocked from Salyut 6 1980 Dec 9.43. It was deorbited over the Indian Ocean 1980 Dec 11.58.

1980-80A, Cosmos 1213 was recovered 1980 Oct 17, lifetime 14 days.

1980-86A, Cosmos 1218 was recovered 1980 Dec 12, lifetime 43 days.

1980-96A, Cosmos 1224 was recovered 1980 Dec 15, lifetime 14 days.

General note:

ESMC stands for *E*astern *S*pace and *M*issile *C*enter, formerly listed as the Eastern Test Range.

SOVIET MANNED SPACE FLIGHT 20 YEARS ON

By Boris Belitsky

Introduction

It was 20 years ago, on April 12, 1961, that Yuri Gagarin made his pioneer spaceflight, followed three months later by his visit to Britain, in the course of which Dr. W.R. Maxwell, as President of the British Interplanetary Society, presented one of the Society's first Gold Medals to him. Today, 20 years on, the Soviet Union is pursuing a vigorous and dynamic space programme, which centres on manned orbital stations, described by President Brezhnev as providing "man's highroad into space."

Salyut: A Success Story

Work on the *Salyut* orbital research station began in 1970, when it had become clear that the problem of spacecraft rendezvous and docking had been solved. The first Salyut station - intended primarily for flight verification of the basic design concept - was launched in April the following year and remained in orbit for just about six months. Its operation confirmed the correctness of the principles embodied in its design and led, despite some early problems and setbacks, to the consecutive launching of five more *Salyut* stations in the 'seventies. By far the most successful of these has been the latest, but not quite the last of the series *Salyut-6*.

The early *Salyut* flights showed that a single cosmonaut requires 10 kilograms of consumables daily to support life aboard an orbital station. Add to this the propellant needed for attitude control and orbital manoeuvre, and it becomes clear that a station would have to carry no less than 20 tons of life-support consumables and propellant when being launched for a two-year manned flight. Since this exceeds the mass of the entire Salyut-6 station, it is obviously out of the question.

The problem was solved, and prolonged flight aboard the station made possible, by the development of the *Progress* unmanned cargo/tanker craft, based on the *Soyuz* design. Work on *Progress* began in 1973, as did work on *Salyut-6*, which involved major redesign of the original *Salyut* engine system to accomodate a second docking port, at the rear end of the station, to receive either manned *Soyuz* (and recently the more advanced *Soyuz*-Transports or unmanned *Progress* resupply craft. Since the station's launching in September 1977, its operation for three and a half years - and the consecutive space endurance records established aboard it of 96, 140, 175, and 185 days - have demonstrated both its success as a product of Soviet space technology and its value as an orbital research facility.

Soyuz-22: A Milestone

Sixty per cent of the cosmonauts' working hours aboard *Salyut-6* have been devoted to studying the Earth and its atmosphere - either by visual observations or with the aid of instruments developed in the Soviet Union, the German Democratic Republic, and Bulgaria. This has yielded a total of ten thousand multispectral pictures alone.

Whereas Gagarin, the first observer of our planet from orbit, could only gasp at its beauty, present-day *Salyut* crews are able to supplement their visual observations (which, by the way, continue to yield information of considerable value) with multispectral photography and a host of other instrumental techniques. And the direct participation of human observers in this work gives such Earth studies from space, in the opinion of Soviet experts, a very definite advantage over the performance of even the most sophisticated *Landsats*, if only because of the constant readiness of a human operator to recognise new and unexpected information as such, to analyse it, and to take unprogrammed decisions, prompted by the situation.

A milestone in the development of Soviet remote sensing was the Bykovsky-Aksyonov flight aboard *Soyuz-22* in September 1976, in the course of which the MKF-6 multispectral camera array was used for the first time, and with excellent results. A splendidly illustrated big-format book [1] with a detailed account of this mission has since been put out jointly by the Academies of Sciences of the USSR and the GDR, where this camera system was developed. It contains some of the colour-coded pictures of various areas in the two countries, which were among the results of the *Raduga* remote-sensing experiment during this flight, with the findings derived from their deciphering. Pictures of Lake Baikal, for example, furnished new information about the geological structure of its rift zone and the distribution of suspended matter borne into the lake by the Selenga river.

A New Philosophy of Earth Studies

The list of examples illustrating the value of Soviet remote sensing - especially resulting from the use of the modified MKF-6M camera and other advanced instruments aboard *Salyut* stations - could be continued far beyond the natural limits of a general survey of this type. Readers interested in the detailed analysis of Soviet remote sensing results are therefore referred to the new Soviet journal *Earth Studies from Space*, which is appearing in English from the beginning of 1981 and which the writer of this article helps to translate for that purpose. Leaving aside such detailed results - as fascinating as some of them unquestionably are - let us, instead, briefly summarise the more general philosophy underlying Soviet studies in this area.

In the view of Dr. Alexander Sidorenke, a Vice-President of the USSR Academy of Sciences and the Editor-in-Chief of the above-mentioned journal, remote sensing from orbit - the very possibility of which few, if any, scientists anticipated even after Gagarin's pioneer flight - is yielding so much fundamentally new information that there is every reason to speak of a new stage in the Earth sciences. Nor is it just a case of each of these sciences being profoundly influenced individually. The large-scale view of the Earth's surface that a vantage point in space affords, moreover at regular intervals, has revealed a number of new phenomena and provided a unique tool for studying the dynamics of others. Furthermore, once spacecraft are in orbit, their operation costs much less than the maintenance of ground services for similar, but not entirely equivalent, work. Accordingly, Soviet scientists expect the eventual saving from the use of space facilities for economic needs to reach thousands of millions of roubles a year.

One of the most significant new developments in Earth studies resulting from remote sensing is, in Dr. Sidorenko's opinion, the "integration effect," i.e., the view from orbit integrates individual features on the Earth's surface into a pattern, which lends itself to scientific interpretation more readily. The orbital vantage point provides an "in-depth" view of both dry land and oceans, with the added advantage of simultaneous observations of transient phenomena in the Earth's atmosphere, hydrosphere, and vegetation. In many cases this is enabling scientists to take the important step forward from a merely descriptive statement of facts to exact qualitative and quantitative evaluations.

Towards "Factories in Space"

Orbital research on the industrial potential of space is second in terms of "cosmonaut working hours" only to Earth studies. The overall effect of this research to date has been to confirm the feasibility of "factories in space", a project first suggested by the Russian space pioneer Konstantin Tsiolkovsky as early as 1926[2].

Following the first materials-processing experiments in space by Shonin and Kubasov aboard *Soyuz-6* in 1969, such work was continued aboard various other Soviet spacecraft and sounding rockets, and aboard *Skylab* in 1973-74, in the Soviet-American Apollo-Soyuz Test Project in 1975, and aboard the *Salyut-4* and *Salyut-5* stations in 1974-76[3]. But it has been aboard *Salyut-6*, since the end of 1977, that particularly notable strides towards "factories in space" have been made.

Zero-Gravity Physics

As Dr. Sergei Grishin, a leading Soviet authority in this field, has stressed, the industrial potential of space can be developed only on the basis of zero-gravity physics, which is concerned with the distinctive behaviour of matter at zero - and micro-gravity conditions.

Accordingly, there has been a great deal of Soviet research, since the early 'seventies, in the theoretical principles underpinning materials processing* in space. This has covered the application of hydrostatic principles to various processes in space, surface tension effects at zero- and micro-gravity, convective processes and heat - and mass-transfer in space, and gravity effects in crystallisation[4].

More recently such research has been facilitated by the development, at the Institute of Mechanics Problems of the USSR Academy of Sciences, of methods of mathematically simulating materials processing in space[5]. Mathematical simulation work of this kind may be expected to gather momentum, specifically in the direction of: (a) the construction of more sophisticated models for the study of zero-gravity effects on materials, and (b) the development of specific models of various processes, taking into account the geometry, boundary conditions, properties of substances, etc. in these processes.

Encouraging Results in Materials Processing

The experiments carried out by the *Salyut* crews so far have confirmed that production at micro-gravity can substantially improve the quality of various materials, both organic and inorganic. This is true of metals and alloys, semiconductors, optical glass and ceramics, and biomedical preparations. This being so, Soviet experts believe that production in space will be of substantial economic benefit.

As far as space metallurgy is concerned, successful experiments in producing aluminium-tungsten composites were carried out aboard the *Salyut-6-Soyuz* orbital complex as early as 1978. Even more encouraging are the results obtained under micro-gravity in preparing immiscible alloys, which are so difficult to prepare on the ground because the components tend to segregate according to density. Orbital experiments have shown that they can readily be produced under micro-gravity, since a weak gravity force does not prevent the components from forming a homogeneous liquid provided the temperature is high enough to increase their solubility. The subsequent testing of the space-produced alloys on the ground proved them to have high strength, wear-resistance, and other valuable characteristics. The *Salyut-6-Soyuz* experiments have also included the preparation of superconducting materials, for example by impregnating porous molybdenum with liquid gallium[6].

But it is with semiconductors that the majority of the Soviet materials-processing experiments to date have been concerned. This is quite understandable in view of the "microprocessor revolution" now so widely predicted in the world, i.e., the relatively small amounts of these materials required (in terms of weight and volume), and the marked dependence of many semiconductor properties on the technology of their production, gravity, particularly, influencing many of the processes involved.

Because the homogeneity of component distribution in single crystal growth is especially subject to gravity effects, the growth of crystals at micro-gravity minimises such harmful gravity segregation. Furthermore, the absence of convection in the liquid phase has been found to stabilise the temperature field and reduce microsegregation, the formation of lamellae, dendrites, etc., while the higher temperature gradient near the growth surface makes for a steadier crystallisation front. All of these factors and several others (e.g. the absence of convection in the gaseous phase and the availability of a high vacuum) tend to improve crystal structure and homogeneity, and facilitate quality production.

Analysis of the monocrystalline slabs of germanium produced aboard *Salyut-6*, and mentioned by Grishin and Leskev in an article in *Spaceflight*, has revealed that inhomegeneities in the distribution of impurities (gallium) have been slashed from 12 to 2 per cent, and the density of dislocations has been reduced from 10^5 to 10^2 cm^{-2}.

Soviet experts are also pleased with what has been accomplished in producing such semiconductors as gallium arsenide in space, since this is a basic material in photo-electric and microwave devices. Another important semiconductor that appears to lend itself well to production in space is cadmium-mercury-telluride, which is so valuable in infrared instrumentation.

Future Trends

The results obtained in space metallurgy and, especially, in producing semiconductors in orbit have suggested a number of trends that further work in this field could follow.

On the one hand, we may expect considerable advances in the research facilities used. One step has already been taken in this direction. The three-man crew who made a flight to *Salyut-6* aboard the new *Soyuz-T-3* transport at the end of 1980 employed holography in space for the first time. The use of holoraphy in metallographic studies has for some time been pioneered in the Soviet Union by the Moscow Institute of Steel and Alloys, but for the needs of materials-processing research in space an entirely new, portable holographic installation had to be designed by the Moscow Physics-Technical Institute. The installation, with the gas laser and optical system, weighs less than 5 kg and is, moreover, immune to vibration. Following evaluation of this equipment during the *Soyuz-T-3* mission, an entirely new, effective instrument is now available for materials-processing work in space.

We may also expect substantial improvements in the electric heating installations used in such work. The *Splav* and *Kristall* furnaces were designed to attain maximum temperatures of 1,000-1,200° C. These furnaces will, no doubt, be significantly uprated to make possible work at higher temperatures, with bigger samples, and employing molecular-beam and other techniques.

All this should substantially increase the range of materials prepared in micro-gravity conditions and make it possible to proceed gradually to pilot-plant production of the most promising of them in orbit.

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3. Sergei Grishin and Leonid Leskov, "Into Space for New Materials", *Spaceflight*, **22**, 3, March 1980, p.142.
4. See, for example, *Gidremekhanika nevesomosti* (Zero-Gravity Hydromechanics), Ed. by A. Myshkis, Moscow, *Nauka* Publishers, 1976 (in Russian).
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* There is a pitfall here for the English reader. In the Russian literature it is customary to describe research in this field as "technological experiments", which is somewhat confusing to English readers accustomed to associating the term "space technology" with space hardware. For this reason it is more appropriate to translate such "technological experiments" in the Russian papers as "materials-processing experiments," which is their equivalent in the English literature.

CORRESPONDENCE

"Kosmolyot" and Soyuz T

Sir, Mr. Christy's comments (*Spaceflight*, February 1981 pp 62) deserve some comments in reply. Whilst I totally agree with his final comment about assuring the quality of data I should like to make a few points about the "Kosmolyot" speculations.

No opinion poll was conducted. I maintain no regular correspondence or contacts with any other Soviet spaceflight enthusiasts and thus work from the published materials (including radio broadcasts and lectures) to present what is, I hope, a fair, balanced view of the achievements of the Soviet space programme.

It was, and still is, my considered opinion based upon the information I have available from the sources listed in part 1 of the Mission Report that the majority of writers on the Soviet space programme were expecting some flight activity related to a Soviet Space Shuttle to commence in the near future. Up to the launch of Soyuz T little space was devoted to the improved Soyuz version being developed. Perhaps my impression is wrong; maybe I read the wrong magazines....

The speculative content of the sentence is quite apparent being in parentheses and prefixed by the word "probably". I accept responsibility for any misunderstanding this may have caused; that suggestion is speculation.

Mr. Christy is mistaken when he says that the name "Kosmolyot" has originated from the West. The Italian magazine *Air Press* on 9 October 1976 (translation provided by Anthony Kenden) stated "As early as 1962 Prof. Artem I. Mikoyan, the well-known designer of MIG aircraft, was the first to use the expression "Kosmolyot", which literally means Space Aircraft...." Writing in *Spaceview* magazine, Vol 7 No. 3 (1976), Maarten Houtman stated "The Soviet shuttle system, called KLA for short, and baptized recently "Albatros" seems to be much more advanced than the US type, currently under construction."

I do hope these points will clear up some of Mr. Christy's comments.

I should like to take this opportunity to correct some times for mission events which were unconfirmed at the time of the publication of the articles on Salyut in the Mission Report series. Soyuz 34 undocking time should read 0907 GMT (part 2). Soyuz T-2 undocking time confirmed as 0925GMT, landing at 1237 (part 5).

NEVILLE KIDGER,
Morley, Leeds,
West Yorkshire.

Language and the Search for Intelligence

Sir Michael Taylor [1] thinks the view of language expressed in my article [2] is somewhat naive. He seems to imply that language predetermines our experiences, with the corollary that without language we could experience nothing. The facts that apes (without language) demonstrate human-like creativity and problem solving, and that man is a neotenous ape, clearly suggest a distinction between linguistic signs and concepts, and thus that the latter can exist independently of language. I could also give many other examples.

The vocabulary of different cultures varies because they have different ranges of concepts, and different needs. Eskimos have many more words for types of ice and snow than we do. They have found it necessary to refine their concepts, and stabilize their inventory of concepts by labelling each with an individual word. Although the existence of words may suggest static concepts new words are continually being coined or borrowed from other languages, or old ones acquire new meanings. The relativist and classical physicist employ the same words, such as 'matter', 'energy', etc., and yet mean very different things by them: they literally have different concepts. The meanings changed because the old concepts were found to be inadequate.

The use of language in the case of the triangle Taylor employs is merely to direct attention to certain aspects in turn, hence induce different perceptions. This is, in principle, possible without language. The great differences in behaviour between humans with language, and those animals without (including young and feral humans), is due to the fact that language can evoke concepts, hence images, independently of the immediate sensory input, and is thus an immense aid to imagination.

It must be remarked that terms like 'justice', 'truth', etc., are not concepts but merely words: they gain their meaning by ultimately referring back to perceived situations. For example, the word 'profound' is related to the Latin 'fundus' meaning 'bottom': in fact, we still use the same word to describe the 'depth' of a well as of the 'depth' of thought. The perceptual origin of *all* such words can likewise be indicated.

The creative act (equivalent to insight thinking) *is* characterised by both irrationality and spontaneity (see [3]). Ordinary thinking incorporates both sequential and insight thinking though, through familiarity, we tend to ignore this [4]. Logical thinking represents only a relatively minor part of this and is, in any case, a human invention enabling us to draw conclusions, develop disciplined thinking, etc., from previously established concepts [5]. For basic theoretical reasons, related to Godel's theorem, our concepts or hypotheses cannot be logically deduced from the facts they are intended to explain. Thinking machines, like the brain, must not be confused with logical machines, like the digital computer.

E.J. COFFEY,
London, N.19.

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SPACE AFFAIRS

Concluded from page 146

Mr Thorn. – I repeat what I have just said, i.e. that in our view, cooperation of this kind could be of some interest to the Community, but that no proposal or request has as yet been placed before the Council and that I am therefore unable to say as a matter of general principle on behalf of the Council whether or not it would be in favour of granting aid. Broadly speaking, however, I repeat that I share your opinion to the effect that the question is one of general importance and interest for the Community and should like to stress that, for example, in the context of the Euro-Arab Dialogue, we have already considered cooperation in this field - this idea dates back to the Copenhagen Summit. We hope that it will be possible to deal with the question with which you are concerned as part of the planned resumption of the dialogue which is planned for the coming months.

THE BRITISH INTERPLANETARY SOCIETY
LIMITED *(by guarantee)*

27/29 South Lambeth Road, London SW8 1SZ

NOTICES OF MEETINGS

Lecture

Title: **THE PHILATELY OF THE SOVIET SPACE PROGRAMME**
by Rex Hall

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on Wednesday **29 April 1981,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

INTERSTELLAR STUDIES MEETING

DAEDALUS-IN RETROSPECT

A one-day discussion meeting on Project Daedalus, three years after the completion of the study, is to be held in the Golovine Conference Room on **6 May 1981,** between 09.30 and 16.30.

The Daedalus concept will be reviewed in light of work appearing since the study, and various areas of investigation stimulated by the Project will be discussed.

Offers of short contributions to the discussion should be made to Dr. A.R. Martin, c/o The British Interplanetary Society, 27/29 South Lambeth Road, London, SE8 1SZ, England.

Registration is necessary and further particulars can be obtained from the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ, England enclosing a stamped addressed envelope.

Film Show

Theme: **THE MAKING OF AN ASTRONAUT (PART 1)**

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **20 May 1981,** 7.00-9.00 p.m.

The programme will be as follows:
(a) Flight of Monkeys and Mice in an Aerobee Rocket

(b) Fluids in Weightlessness

(c) Science Reporter - Suited for Space

(d) Project Gemini Test

(e) The Four Days of Gemini 4

(f) Legacy of Gemini

The programme will be repeated later, if warrented by demand.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Title: **PLANET 10 - THE GIFT FROM GALILEO**
by A. T. Lawton

The theme is based on a very recent discovery that Galileo saw and recorded the planet Neptune in 1612.

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on: **27 May 1981,** 7.00 - 9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Technical Forum

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 on Friday **29 May 1981,** 6.30-9.00 p.m. and Saturday **30 May 1981,** 10-12 noon and 1.30-3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet Space Programme are invited to attend. A registration fee of £1.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

Lecture

Title: **SPACELAB**
by Dr. M.J. Rycroft

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on Wednesday **3 June 1981,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Open to members of the Society both in the UK and USA

SOLAR ECLIPSE JULY 12 - AUG. 2, 1981

The Southern California Branch is organising a group expedition to view the solar eclipse on 31 July 1981. The tour will include visits to many astronomical, archeological and historical sites leaving by air from London to Peking and travelling by rail through Ulan Bator and Irkutsk to Bratsk, where the group will view the eclipse. Return will be through Moscow.

Arrangements will be in the hands of Mr. R.V. Frampton, Mail Stop 264-519, Jet Propulsion Laboratory, Pasadena, California 91103, USA.

Members interested should contact Mr. Frampton for further details.

Total cost from London will be about £1560 ($3595)

Lecture

Title: **The ARIEL 5 and 6 EXPERIENCE**
by Dr. M.J. Ricketts

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **2 September 1981,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Continued on back cover

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

32nd IAF Congress

The 32nd Congress of the International Astronautical Federation will be held in Rome, Italy from **6-12 September 1981.**

The theme will be:

SPACE: MANKIND'S FOURTH ENVIRONMENT

devoted to "promoting awareness about the challenges and debating the problems posed by the use, further exploration and management of this fourth environment." The theme will then be developed through a series of symposia and technical sessions organised by the IAF and by the International Academy of Astronautics (IAA).

36th Annual General Meeting

The 36th Annual General Meeting of the Society will be held on **26 September 1981**

Details of the Agenda and Venue will appear in *Spaceflight* shortly.

Nominations are invited for election to the Council. Forms can be obtained from the Executive Secretary. These should be completed and returned not later than 3 July 1981.

First Night

An opportunity for new members of the Society (and interested guests) to meet members of the Council and Officers of the Society will occur on **7 October 1981,** at the Society's HQ Building, 27/29 South Lambeth Road, London, SW8 1SQ, 7.00-9.00 p.m.

It will be an informal evening in which members can hear about the History and Activities of the Society, see a space film and have an opportunity for a short guided tour of the Building.

New members who would like to attend are invited to apply in good time, enclosing a reply-paid envelope.

Lecture

Title: **RECENT ADVANCES IN SPACE FLIGHT**
by P.S. Clark

A review of space activities throughout the world which have taken place during the past twelve months, to be held in the Golovine Conference Room, Society HQ 27/29 South Lambeth Road, London, SW8 1SQ, on **14 October 1981,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **OBSERVATIONS OF THE ATMOSPHERE OF VENUS FROM THE PIONEER ORBITER**
by Dr. F.W. Taylor

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **18 November 1981,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show

Theme: **THE MAKING OF AN ASTRONAUT (PART II)**

Further stages in the development of manned space voyages will be illustrated in the following film programme which will be screened at a meeting to be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **2 December 1981,** 7.00-9.00 p.m.

The programme will include the following

(a) The Hard Ones

(b) Gemini 11 - Quick Look

(c) Spaceship Skylab - Wings of Discovery

(d) The Mission of Apollo-Soyuz

(e) Space Shuttle - Overview

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

SPACE TRANSPORTATION WORKING GROUP

Members having technical expertise in space transportation systems and who are prepared to participate in a Discussion Group should contact the Executive Secretary for further details.

A UNIQUE HISTORY OF YOUR SOCIETY

"HIGH ROAD TO THE MOON"

Every member of the Society ought to possess a copy of this unique new publication which records many of the Society's original ideas and discussions on Lunar exploration through the visionary drawings of the late R. A. Smith.

The pictures visualise the ideas on orbital rockets, space probes, ships to take men to the Moon and Lunar exploration itself. Some are familiar illustrations, others have never been published before.

Now, Dr. Bob Parkinson has brought these pictures together with a commentary which tells how the Society's pioneers imagined things would be and how they were. But the story goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

R. A. Smith, a former President of the Society, died in 1959. He had been one of the pioneers of the Society and left behind him a collection of nearly 150 paintings and drawings which recorded one of the most visionary periods in its history.

The book runs to 120 pages in large (A4) format and about 150 illustrations.

Price £6.00 ($16.00)

Printed by Smartprint Publications Ltd., North Street Trading Estate, Crewkerne, Somerset, TA18 7AW, and Published for The British Interplanetary Society Ltd., (No. 402498) by Space Educational Aids Ltd., (No. 741211). Registered Office, 27/29 South Lambeth Road, London, SW8 1SZ, England.

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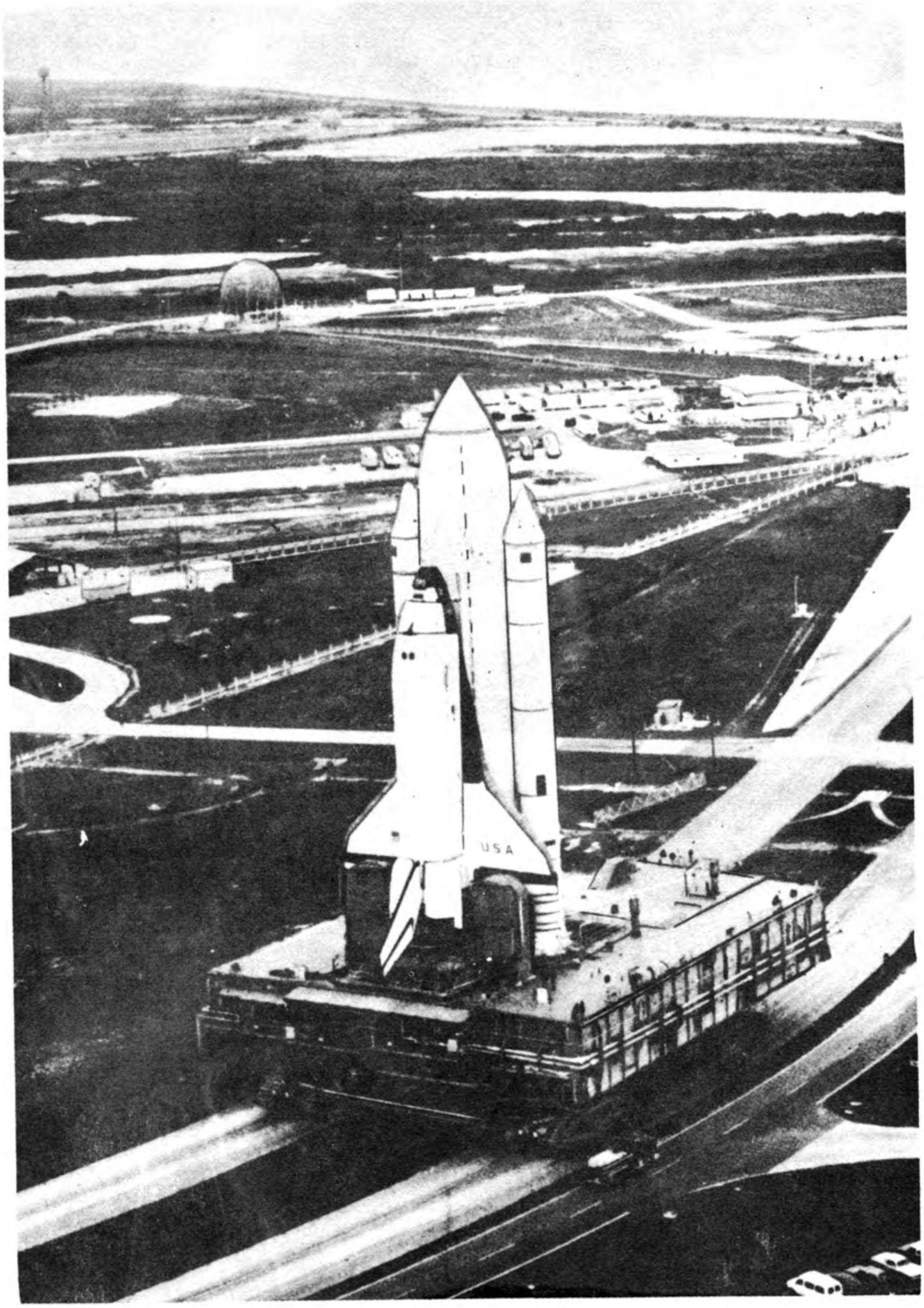
SPACEFLIGHT



Published by
The British Interplanetary Society

VOLUME 23 No. 6
JUNE 1981

Voyage To Saturn

Voyager took about 17,000 images during its brilliantly successful encounter with Saturn last November. A little over sixty were generally released and we have pleasure in making them available to customers now. We were planning to produce one of our own sets of 12 slides but we were considerably impressed by the Holiday Film set of 18 slides — which comes in a plastic wallet with an extensive, colour commentary sheet — so we are importing this in bulk and it can be purchased from stock.

Code No: 18-20 Voyager's Saturn Encounter

Price £5.50

(16 colour slides — 2 black and white)

OTHER VOYAGER PRODUCTS

A range of other Holiday Film products of the Saturn encounter has been produced but all of these will be imported specially on receipt of customers' orders so up to eight weeks should be allowed for delivery.

Code:	40-87	40 slides with cassette	**Price £10.00**
Code:	VS-62	62 slides in a box. (Mounts are captioned but there is no cassette or commentary sheet)	**Price £16.00**
Code:	XA-136	Five slide sleeve	**Price £1.75**
	XA-137	Five slide sleeve	**£1.75**
	XA-138	Five slide sleeve	**£1.75**
Code No:	1535	Complete coverage silent movie. Super 8 only. Includes time lapse sequences of the rotation of Saturn and its rings, orbiting moons, etc. Mixture of black and white and colour.	**Price £16.00**

NEW CUSTOMERS PLEASE NOTE. Generally speaking there is duplication between the various Holiday Film sets. Thus the slides in the 18-slide set will be included in the 40 and 62 slide selections — similarly, the 40 and 62 slide selections will contain the slides included in the three 5-slide sleeves. Thus — according to the size of selection wanted — customers are advised to order the 18 *or* 40 *or* 62 *or* the five slide selections.

SPACELAB

Although the first flight of the ESA built Spacelab must await completion of the early test flights of COLUMBIA, the official NASA-ESA embroidered emblem is already available. The oval patch shows a plan view of the Shuttle and Spacelab module against a disc of Earth. The words appearing are *NASA-ESA Spacelab Mission* 1. Over ten colours are used in the patch which is $5\frac{3}{4}''$ across by $3\frac{1}{2}''$ deep. From stock.

Price £2.50

VIKING - A NEW POSTER

America on Mars — Vikings Explore Red Planet is a NASA educational poster (NF75/3-77) containing a large number of black and white and colour pictures taken by Viking orbiters and landers, artists' impressions of mission procedures and a text summarising mission results. Measures a massive 48″x 31″. Posted folded. From stock.

Price £2.50

MOUNT ST HELENS

The dramatic events last year when Mount St. Helens in the US erupted need little stressing by us. Holiday Film Corporation has now produced a first class set of 18 slides showing the volcano before the eruption, the shattering events of the eruption itself as seen from the surface, the air and space, and the aftermath. The extensive full colour commentary sheet not only analyses the events at Mount St. Helens but provides very useful background on volcanoes generally. This set will be particularly valuable for schools. Available from stock.

Code No: 18-17 **Price £5.50**

For UK customers all prices include VAT and postage.
Foreign customers should increase the list prices as follows:
Europe: Surface post – add 10%. Airmail – add 20%.
Outside Europe: Surface post – add 20%. Airmail add 40%.

SPACE FRONTIERS

Space Frontiers Limited (Dept. SF/81/1)
30 Fifth Avenue Havant Hampshire PO9 2PL England
Telephone Havant (0705) 475313

SPACEFLIGHT

A Publication of The British Interplanetary Society

VOLUME 23 No. 6 JUNE 1981 *Published 15 May 1981*

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A. Wilson

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COVER

ON THE WAY. Space Shuttle *Columbia* makes its way to the pad mounted on its mobile launch platform. The 3½ mile journey took 10½ hours.

MILESTONES

March 1981

22 Soyuz 39 is launched with cosmonauts Vladimir Dzhanibekov and Jugderdemidiyn Gurragcha aboard to rendezvous and dock with Salyut 6, occupied for the past 10 days by Kovalyonok and Savinykh. Gurragcha, aged 33, had been in cosmonaut training since 1978 and is the first Mongolian to go into space. He is the 8th non-Soviet cosmonaut (the 9th will be a Roumanian).

23 The US is reported to be developing a new method of anti-ballistic missile defence. Lockheed will conduct the first test launches in late 1982 of a missile which will release metal pellets or a heavy umbrella-shaped net into the path of an attacking missile before it has the chance of releasing its multiple warheads.

23 The new Intelsat V comsat, launched 6 December 1980, is used in a three-way link-up during the keynote address to the Fifth International Conference on Digital Satellite Communications in Genoa, Italy. The satellite, Intelsat's first to use the 14/11 GHz frequency band, connected Genoa with Comsat's laboratories in Maryland, USA, while the European OTS satellite provided the service to London.

NASA announce the four experiments to be flown aboard the Gamma Ray Observatory, due for launch in 1988. They are: Transient Event Monitor, High Energy Gamma-Ray Telescope, Imaging Compton Telescope and the Low Energy Gamma-Ray Spectrometer.

April 1981

1 Voyager 2 is 138 million km from Saturn and 1145 million km from Earth as it heads for encounter on 26 August. Voyager 1 flew past the planet on 12 November 1980. If all goes well, Voyager 2 will fly by Uranus in 1986 and Neptune in 1989.

10 An estimated one million spectators gather around Cape Canaveral for the first launch of America's Space Shuttle *Columbia,* the first manned US flight since Apollo-Soyuz in 1975. The countdown reaches T-9 minutes and is stopped because of problems with the vehicle's computers. The problem cannot be solved for that day's launch window and the lift-off is postponed for two days.

12 Pad 39A feels the heat and pressure of a giant rocket once again as STS-1, carrying astronauts Young and Crippen, begins its historic trip. In orbit, the men discover that 16 thermal tiles are missing off the OMS pods. NASA, however, maintain that *Columbia* should still be able to withstand re-entry two days hence.

NEXT MONTH

Members who normally receive *Spaceflight* will be interested to know that next month they will instead receive the first issue of *Space Education*, representing a major step forward in the Society's interests in the educational field.

It is hoped that the new magazine will be welcomed by members; it will not be directed solely at teachers and students but will, equally, be aimed at the broad area of education at all levels.

The first issue will include a survey of career prospects in the astronautics field, a look at the work of space museums, and a report on the British Aerospace/BIS sixth form conference of last year and the BIS visit to Cambridge University's astronomical facilities.

Contributions for the second issue, currently planned for December, will be welcomed.

"COLUMBIA" PREPARES FOR FLIGHT

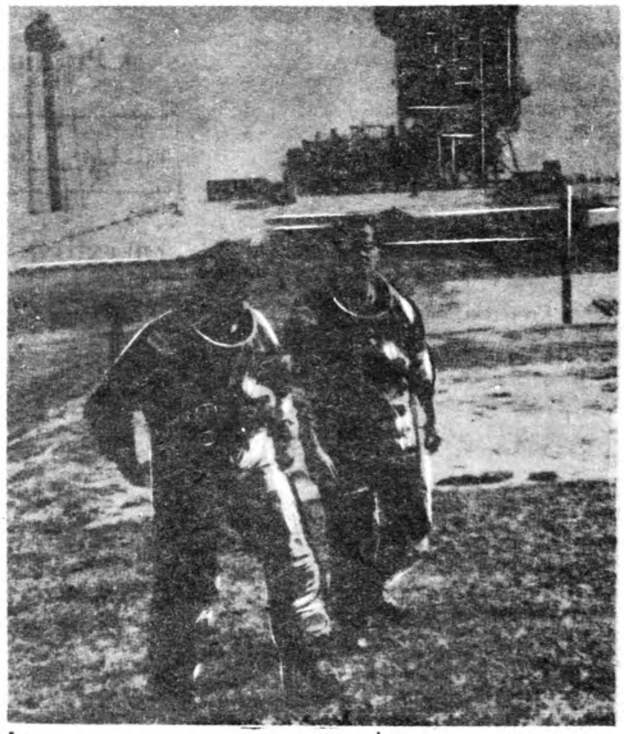
At the time of going to press, Space Shuttle *Columbia* is standing on pad 39A at Cape Canaveral undergoing its final preparations for the first American manned space flight in almost 6 years: soon, we shall know if mission STS-1, flown by astronauts John Young and rookie Robert Crippen, has opened a new era in space transportation or if the immense complexity of this new spacecraft has proved to be too great. NASA has rarely been as wary about announcing a manned launch date - never mind the time! - because any one of a myriad of faults could cause further delays. Even the Apollo lunar flights were more certain, but then they had launch window deadlines to meet whereas this first Shuttle test flight has fewer restrictions.

Introduction

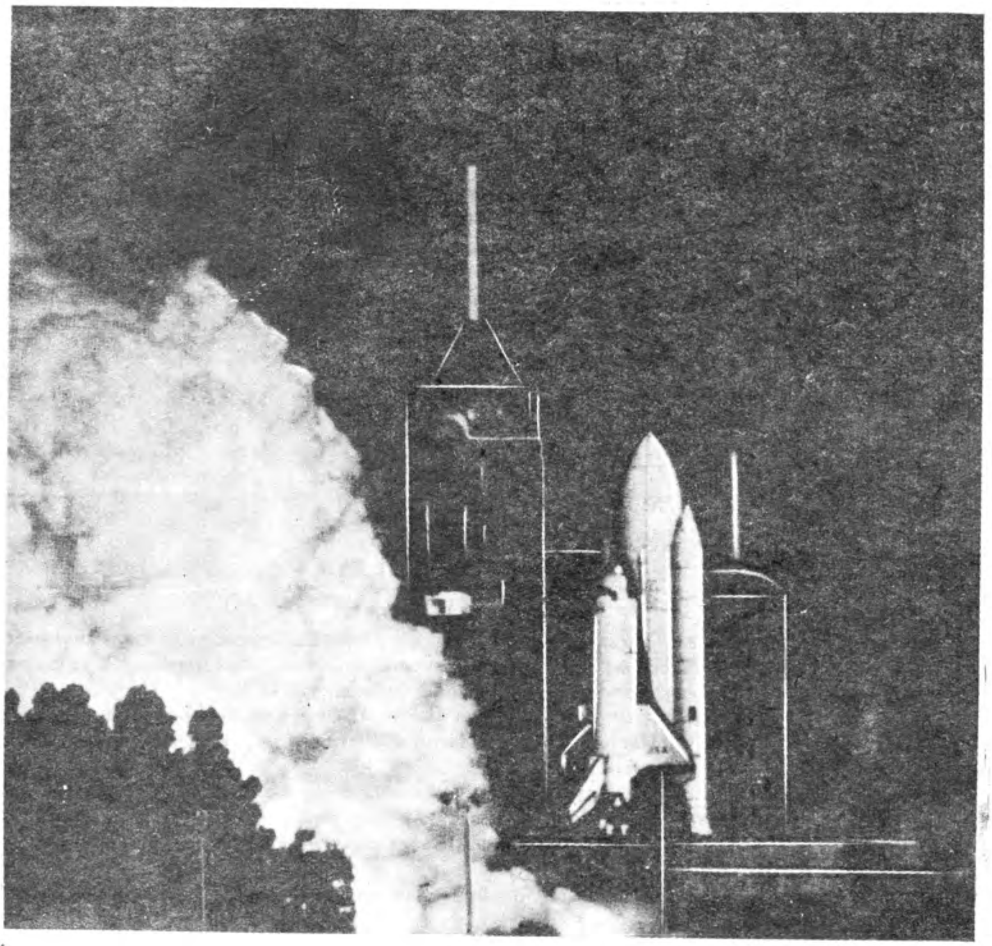
STS-1 was rolled out of the Vehicle Assembly Building on 29 December last year to make the 3½ mile trip out to the pad to begin an extensive series of tests and simulations. The journey took some 10½ hours (an average speed of ⅓ mph!), nearly 4 hours longer than planned because of problems with a propellant fuel line on the launch platform.

On-pad tests

The launcher and its mobile platform were connected to the ground services (power, water, etc.) for Pad Validation Tests to begin on 2 January. NASA announced on 2 February that the launch was being postponed from 17 March to "the week of 5 April at the earliest". Problems had arisen during a cryogenic propellant loading test with the External Tank when it



STS-1 astronauts John Young (left) and Bob Crippen after a training session on the slidewire escape system wearing their full spacesuits (see facing page). The Apollo astronauts used a similar escape route a decade ago.



The Kennedy Space Center hears the roar of the Shuttle main engines for the first time. The crew were not aboard for the 20 second static firing on 20 February.

appeared that the stresses caused by the super-cold liquids had been too much for insulation on the Tank's exterior. An area of about 50 ft² came loose and Martin-Marietta began a 13 day *in situ* repair on 7 March.

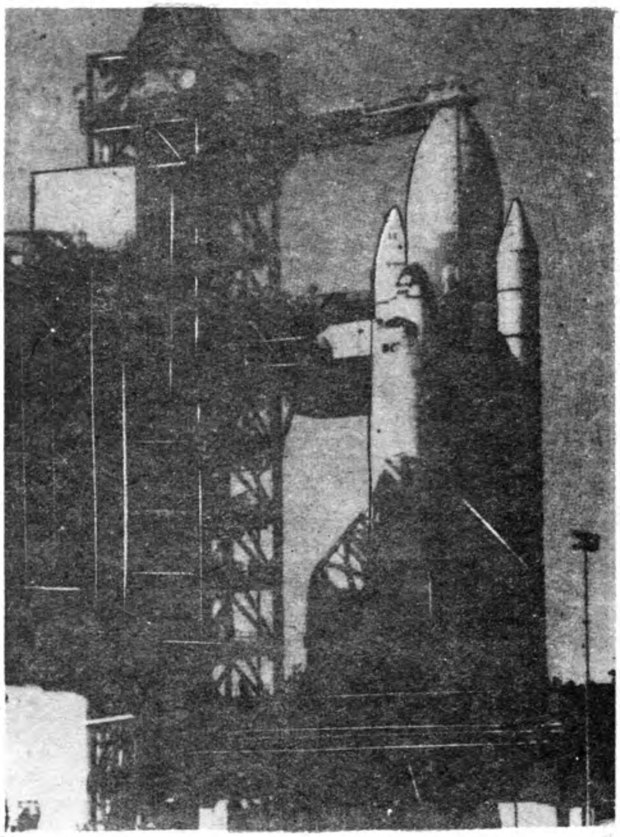
On 10 February, the 11 day Wet Countdown Demonstration Test/Flight Readiness Firing check began, a major hurdle to overcome if the launch was to occur in early-to-mid-April. The exercise included loading cryogenic propellants aboard the Orbiter and its External Tank in readiness for a 20 seconds static firing of the three main engines on 13 February, although delays pushed this back to the 16th and then the 20th. The entire Shuttle system was put under scrutiny - computers, effects of engine ignition and firing on the pad and the Shuttle structure itself, engine control systems (gimballing took place while thrust varied between 94 and 100% of normal) and propellant tanking and detanking procedures. The Shuttle is unoccupied during this latter phase for obvious safety reasons; the crew would normally go aboard soon after completion of ET loading.

A final 2 day dry-countdown demonstration test, the last major hurdle, was completed on 19 March and judged to have been very successful. Tragedy struck, though, when five Rockwell International technicians and one other man went into the nitrogen-filled aft section of the Orbiter. All were affected by the gas (used as a precaution against fires) and 50-year old John Bjornstad died about three hours later.

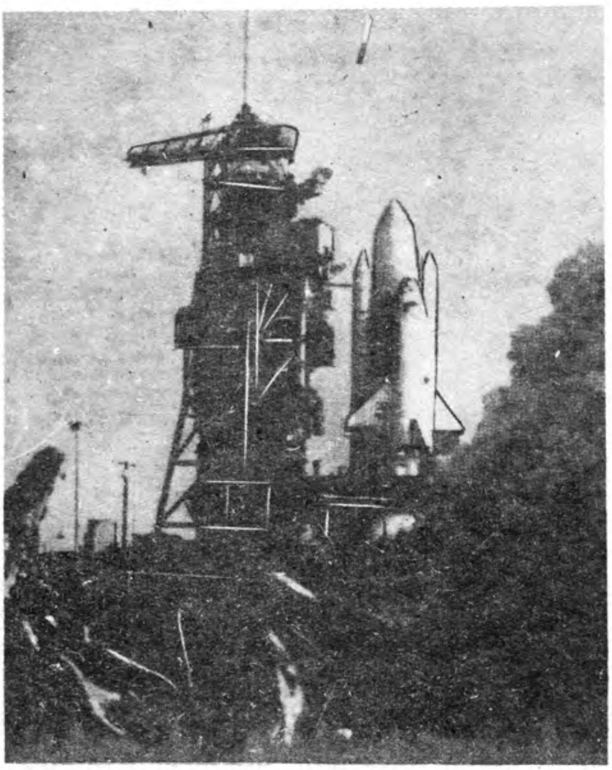
Flight programme

The flight itself was planned to be as simple as possible. Launch weight was kept down to 1.9 million kg instead of 2.04 million kg, and the launch profile was designed to avoid stressing *Columbia's* structure and thermal tiles. The crew quarters below Young and Crippen's seats were also unequipped.

In-orbit tests were, again, simple. Perhaps the most important is the opening of the cargo bay doors. Without the radiators on the doors' insides removing waste heat from *Columbia*, the six tanks of cooling water would be used up in six

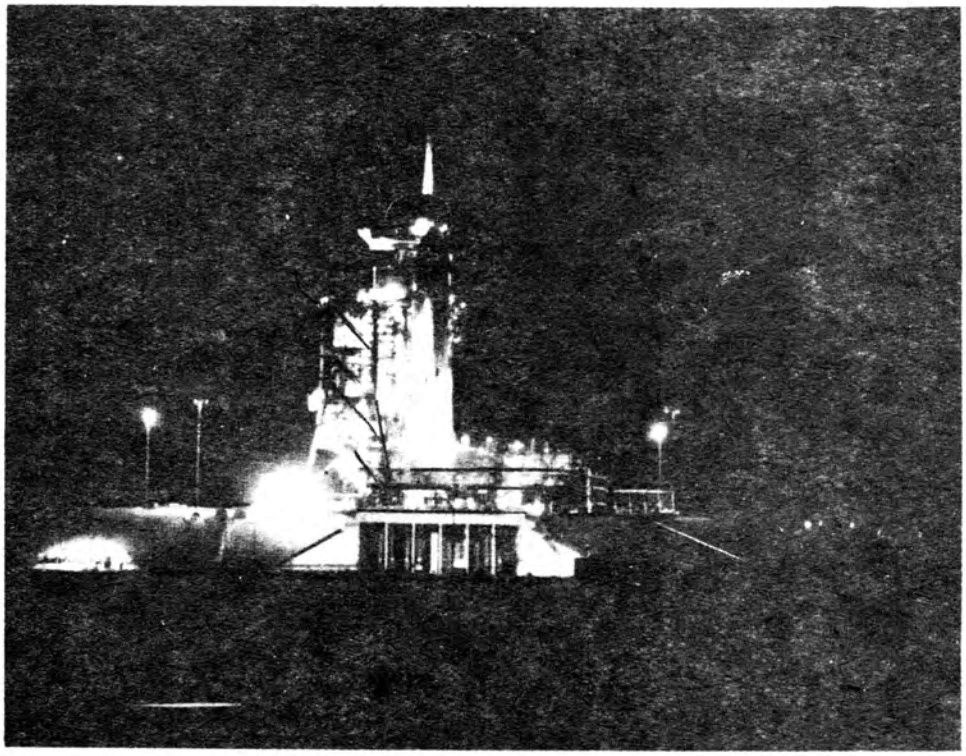


The service structure moves back ready for the engine test.



Another view of the Flight Readiness Firing which took place at 8.45 am local time on 20 February

Young (foreground) and Crippen on the service structure just before testing out the slidewire escape system.



A dramatic night view of *Columbia* during the round-the-clock preparations for the static firing.

Earth revolutions. Closing the doors could cause problems if they warped out of shape - Crippen was trained to go on an EVA to see what he could do if that happened. Other activities scheduled included firing the Reaction Control System, guidance checks and testing the hydraulic control surfaces used during re-entry and landing.

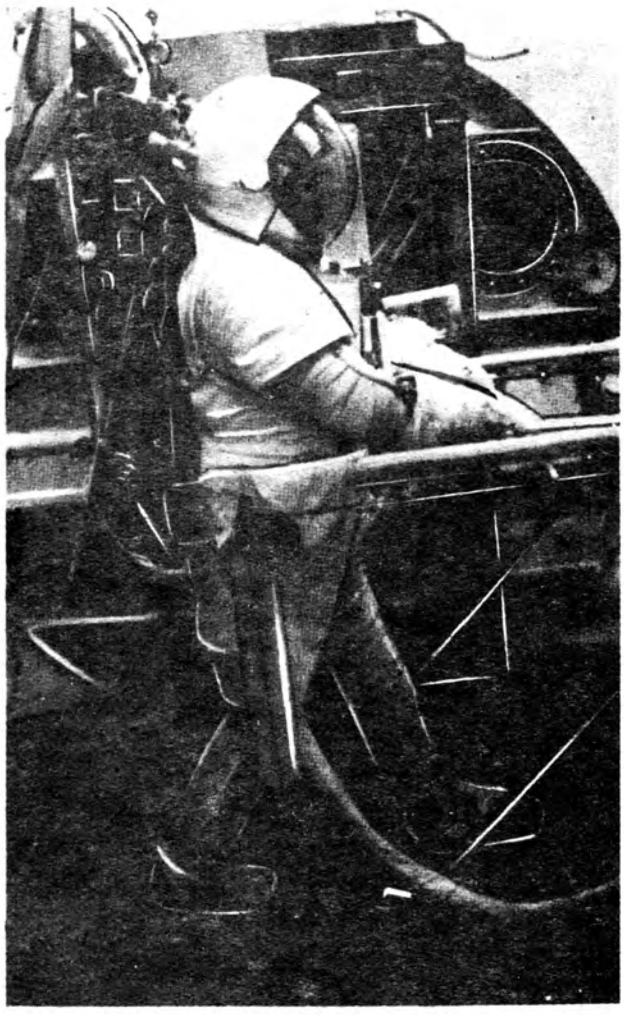
In the words of pilot Bob Crippen, "As far as John and I are concerned, if we get up and get back down, that is a successful mission."

John Young, the most experienced active astronaut (selected in 1962; flew Gemini 3 in 1965, Gemini 10 in 1966, Apollo 10 in 1969 and Apollo 16 in 1972), has perhaps himself reflected on an interesting coincidence going back 9 years to his trip to the Moon in *Casper* and *Orion*. He and Lunar Module Pilot Charlie Duke were on one of their EVAs when news was radioed up that the House of Representatives had approved funding for the Shuttle. Young commented, "The country needs that Shuttle mighty bad." Almost a decade later he would be responsible for commanding the first, vitally important, mission.

Of the Shuttle, Young says, "It's going to be a remarkable thing.... it will help [to] develop science and technology. We'll be able to do in five to ten years what would otherwise take us 20 to 30 years to do using the throw-away rockets devloped in the 1960's."

Four test flights are currently planned, leading to the operational phase in late 1982. It could be, though, that if the first three flights are very successful then the fourth may be dropped (just as the 1977/8 *Enterprise* drop-tests were finished early) to get into the operational phase as soon as possible. At 1981 rates, a single launch carrying four comsats with their geostatinary kick motors would cost each user in the region of $8.5 M - $10.9 M.

We hope to publish a full report of the mission in a future issue of *Spaceflight*.



Right: John Young during part of a 10 hour evaluation test of the Shuttle EVA suit. The suit's life support systems were subjected to EVA-type stress. Note Young's spectacles.

THE INTERKOSMOS PROGRAMME 1967-1980: A BRIEF OVERVIEW

By Neville Kidger

Introduction

In 1967 the countries of the Committee for Mutual Economic Assistance (CMEA) affiliated to the Soviet Union entered into an agreement which envisaged the cooperation of all the member signatories in the field of space research.* Four main areas were defined where studies were to be made:

- Space Physics.
- Space Meteorology.
- Space Communications.
- Space Biology and Medicine.

In 1975 a fifth was added:

- Study of Earth's Resources.

Each country within CMEA finances just their own expenditure. There is no common fund for the programme. The USSR supplies the basic satellite and the carrier rocket. Scientific results are the common property of all the participants of the Interkosmos Programme.

The First Ten Years

In the first 10 years the Interkosmos programme saw the launch of 16 dedicated Interkosmos satellites for scientific research. The last 3 years has witnessed a blossoming of the scope of the programme with the flights of non-Soviet cosmonauts to the Salyut 6/Soyuz Orbital Scientific Laboratory and introduction of an improved basic satellite series.

Regular meetings are held of various groups of workers in the differing scientific disciplines of the Interkosmos programme. In June 1980 the Space Physics group outlined programmes for the 1981-85 five year period which involve studies of Halley's comet and probes to both Mars and Venus.

Intersputnik

The Soviet-controlled Intersputnik communications satellite system was set up in 1971 and is open to all interested members of the world community. In addition to the CMEA countries Yemen is a signatory (at the 9th council meeting in Havana, Cuba, in October 1980 delegations from Nicaragua, Mozambique and Afghanistan were present as observers.

The system was first used in a broadcast *via* a Molniya 1 satellite in November 1973 with a telecast of a visit to Cuba by L. I. Brezhnev. The system was formally inaugurated the following year.

Ground stations for transmission and reception of TV and telephone data are located in many countries. By 28 October 1980 operational ground stations were located in the USSR, BPR, HPR, GDR, Cuba, MPR, PPR, CSSR. In addition the Lotos ground station had been completed in the SRV as well as a station in Algeria. A station is under construction in Laos.

Geosynchronous satellites of the Loutch series are planned for launch over the next few years into the Statsionar 3 (located at 90°E), Statsionar 4 (14°W), Statsionar 5 (58°E) and Statsionar 7 (140°E) orbital slots. The USSR is hoping to remove a substantial portion of the Intelsat revenue with these satellites which are intended as an alternative to the Intelsat system (which is primarily US-controlled).

Unmanned Interkosmos Satellites

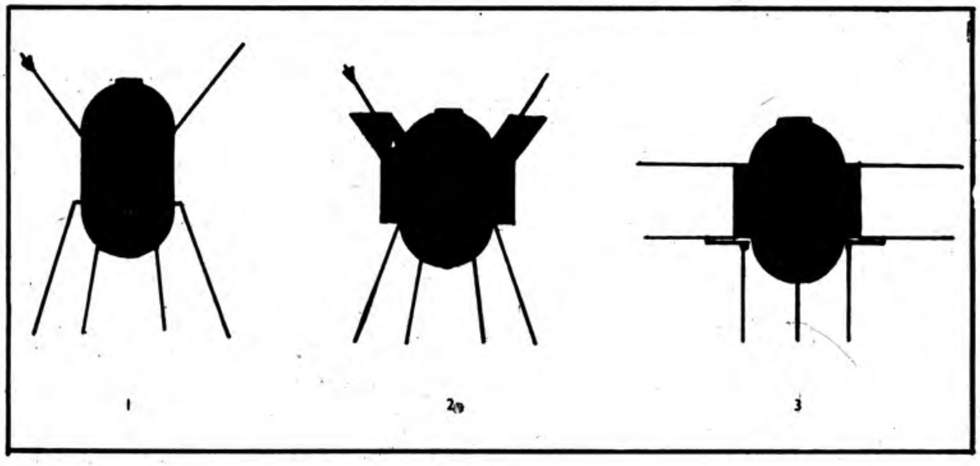
The Interkosmos programme has used 5 basic satellite types to date on which experiments from the CMEA countries were mounted. The first 4 types were used initially within the Soviet Union's domestic Kosmos series. See the accompanying illustrations and table.

Types 1 to 3 are examples of the various modifications to the small basic Kosmos scientific research satellite. This design consists of a cylinder and two hemispheres. The three sections comprise one each for power supply, either battery or solar cell powered, avionics and experiment support. The detectors of the satellite, Interkosmos or otherwise, are located by support brackets and power cables to the latter section. The designs were tested with the Interkosmos hardware on the Cosmos 166 and 230 solar satellites (USSR, GDR, CSSR), 261, 321 and 348 atmospheric and auroral studies (USSR, GDR, CSSR, PPR, RPR).

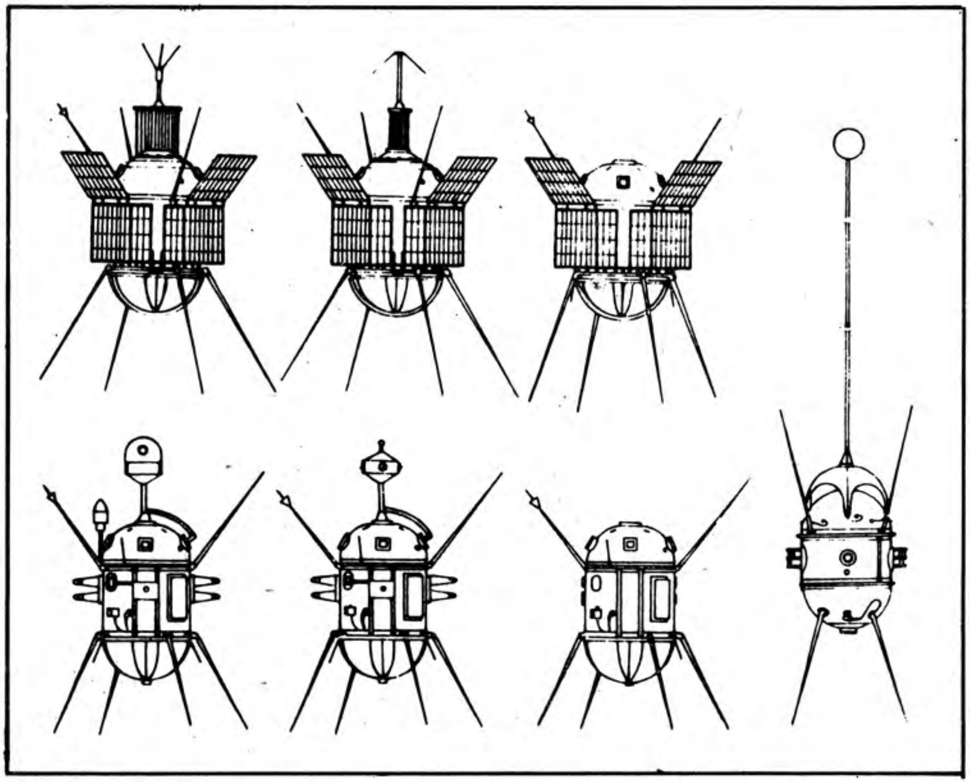
The Interkosmos 6 satellite utilised a Vostok type reconnaissance spacecraft carrying, in place of the normal cameras, a 1 tonne BFB-C photoemulsion unit to study high energy cosmic ray particles. The unit was orbited for 4 days before being successfully recovered in the USSR.

Interkosmos 15 saw the introduction of a new type of satellite which the Soviets term an Automated Unified Orbital Station (AUOS) which features an advanced computer designed to process much of the collected data before transmission to the ground and an Earth-pointing platform.

* *The participants, and signatories of, the Interkosmos programme are: Bulgaria (BPR), Cuba, Hungary (HPR), Czechoslovakia (CSSR), Romania, (RPR), German Democratic Republic (GDR), Mongolia (MPR), Poland (PPR), Socialist Republic of Vietnam (SRV) and the Union of Soviet Socialist Republics (USSR). Apart from the SRV, which became a signatory in 1979, the countries above were founder signatories. In the text of the article the signatories will be referred to by the abbreviation of the title of their states.*



Types 1 to 3 of the Interkosmos satellites. Type 1: ionosphere studies, typical weight 320 kg, flights 2 and 8; type 2: particles/fields studies, typical weight 340 kg, flights 3, 5, 9, 10, 12-14; type 3: solar studies, typical weight 375 kg, flights 1, 4, 7, 11 and 16.



The Kosmos satellites of types 1 and 2 are illustrated here to show how the addition of various instruments enables the same basic bus to be used for a variety of flights and applications.
"Raumflugkorper" Pfaffe Staches, Transpress, Berlin, 1973.

AUOS/Interkosmos 15 reportedly weighed 422 kg and since Interkosmos 17 all the satellites in the series have used the AUOS design. Comparative weights for the first three generations of satellites were: type 1: about 320 kg (IK 2), type 2: 340 kg (IK 3) and type 3: 375 kg (IK 7).

The AUOS satellites are capable of supporting small pick-a-back payloads for jettison once in stable orbit. The first use of this facility was demonstrated on the AUOS/IK 18 IONOZOND satellite which, after almost 3 weeks in orbit, jettisonned the CSSR-built MAGION satellite (wt 15 kg) which was designed to provide data on the upper atmosphere as it drifted away from the parent satellite.

The follow-up launch of AUOS/IK 19 IONOZOND, while not carrying a sub-satellite, conducted joint studies with the IK 18 main satellite to aid in the development of a cross section of the near-Earth ionospheric and magnetospheric environments in spring and autumn periods. In conjunction with the satellite observations, 25 balloons carrying equipment for similar studies were launched from the Swedish range at Kiruna to drift from the west to the east ground stations and small sounding rockets were also fired to aid the programme, a part of the overall observation programme called MAGIC. These studies mapped the same geophysical parameters of plasma, magnetic and electrical fields at the same time from differing heights. About 50 countries participated in the programme. A new ionospheric research programme calling for over 1,000 experiments into magnetic field disturbances was begun in 1979.

Typical Experiment Payload

The payload of an advanced AUOS/IK satellite can be illustrated by describing the instruments carried by AUOS/IK 19 IONOZOND. A total of 9 detectors were carried to study the ionosphere at the peak of the solar cycle.

- ISS-338 Ionospheric station and SF-3 device (both USSR designed) studied photoelectric pulses and showed electron showers with charges varying between 1-150 KeV in the southern hemisphere which were in turn magnetically transmitted to the northern hemisphere.
- EMO-1 optical spectrophotometer (BPR) recorded atmospheric glows in the polar and equatorial regions (20-30° Lat.) in the 51.99-52.01 Å, 63-63.64 Å and 39.14-55.77 Å.
- P-4 device which showed the electron concentration in the upper atmosphere to have peaked in 1979 on both the day and night sides of the Earth to their highest level for 10-15 years. This BPR device was designed to study the concentration and temperature of electrons and ions in the upper atmosphere.
- Other devices carried included the M4K "Mayak" (Beacon) transmitter (USSR), KM-3 (CSSR/USSR), ANC-2ME (USSR), IRS-1 radio spectromometer (PPR) operating between 0.6-6 MHz and the AVC-2 plasma analyser (USSR).

Applications Interkosmos Satellites

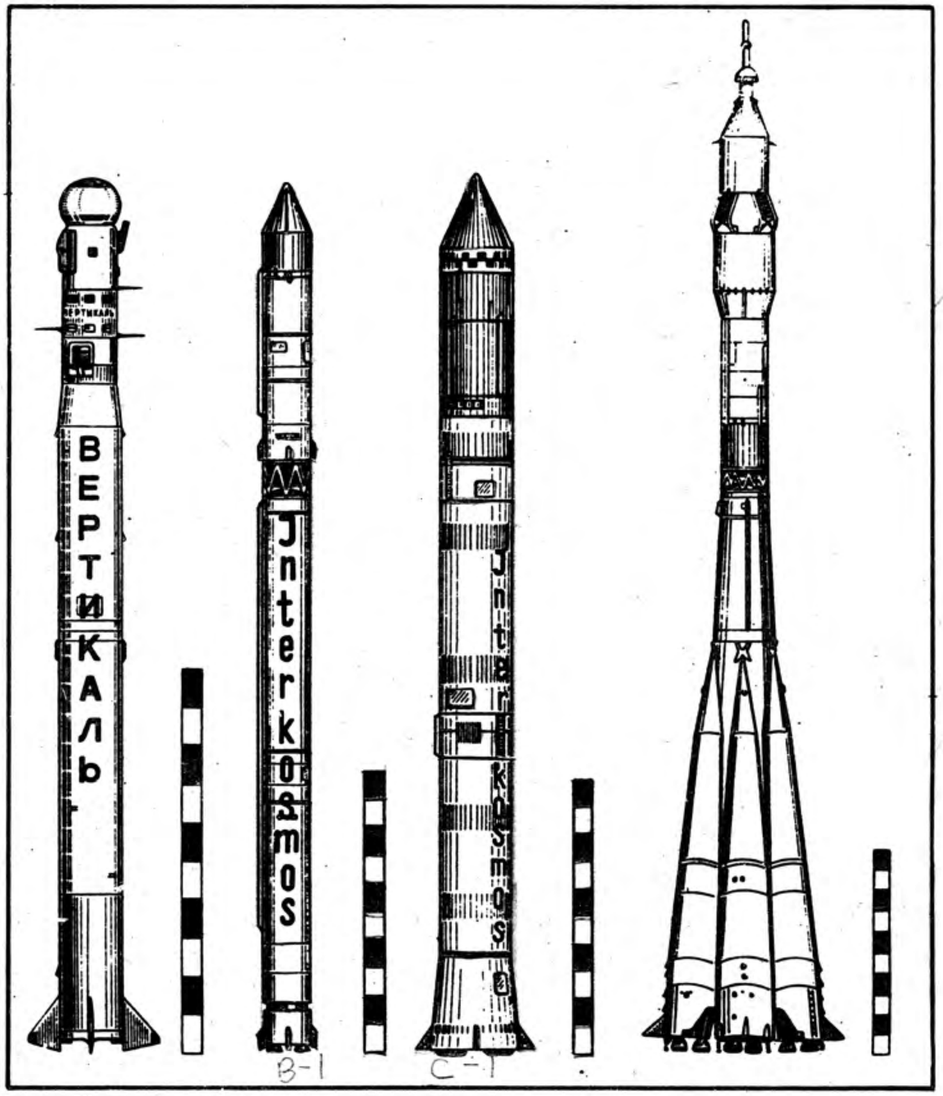
The launch of the AUOS/IK 20 OKEAN satellite opened up a new stage of the Interkosmos programme in that AUOS/IK 20 had a clearly defined *applications* purpose as opposed to a purely scientific basis. AUOS/IK 20 studied the dynamics of the ocean in conjunction with ground and sea-based research facilities. The satellite is able to record information from remote land-based platforms and buoys which collect information on ambient conditions and relay them automatically to the main control centre at Tarusa.

The IR radiometers carried by AUOS/IK 20 are capable of determining sea-surface temperature to less than 1°C. The Interkosmos satellite is smaller than, but similar to, two Kosmos Ocean Dynamics satellites launched in 1979 and 1980. The Kosmos satellites — K1076/OKEAN and K1151/OKEAN — carry IR and microwave installations for remote sensing of the ocean surface state. The Kosmos satellites are launched by the SS-9 ("F" type) carrier rocket. All AUOS satellites are launched by the smaller SS-5 ("C" type) carrier rockets. All launches were from the Northern Cosmodrome at Plesetsk.

Non-Interkosmos Cooperative Spacecraft

Several Soviet Artificial Earth Satellites (AES) have carried equipment and experiments built in other countries. The flights of these AES's are usually (but not always) identified by the

Rockets used by Interkosmos (not to scale). Left to right: V5V geophysical rocket (Vertikal 1), B-1 (Interkosmos 1-9), C-1 (Interkosmos 10 to present), Soyuz A-2 (InterSoyuz flights to Salyut 6).
"Polska w Kosmosie" Elstein, Wydawnictwa Komunikacji i Lacznosci, Warsaw, 1978.



Soviets to a specific mission. This section of the report shows examples of these programmes.

Biosats

Biological Research Satellites (biosats) have been launched by the USSR since the beginning of the space age. The second AES carried the first animal, the bitch Laika, into space on a one-way flight which, after a week in space, saw the animal painlessly put down because the USSR had not yet developed a recovery capability. Laika proved, however, that the organism of a higher order animal was able to withstand the rigours of spaceflight.

The use of dogs was further expanded during the flights of the AES/Korabl ships which, in 1960-61, tested the prototype of the Vostok spacecraft for manned flights. The AES/Korabl ships were able to be recovered after differing periods in orbit.

The improved Vostok variant spaceship has been the mainstay of the USSR's biosat programme since the flight of the dogs Ugolek and Verotok in Cosmos 110. The dogs were recovered, after a flight of 22 days, in good health.

Later flights of the Vostok variant biosat under the Kosmos label carried rats and lower forms of life on approximately 20 day flights. Kosmos 605 and Kosmos 690 were examples of this type of flight.

Interkosmos cooperation in space biology and medicine began after the 1967 accord but it was only in 1974 that agreements were signed to fly experiments aboard the Soviet biosat flights. Study programmes drawn up for the 1976-80 period encompassed studies on space physiology (the analysis of spaceflight conditions and their effects), radiation factors and safety.

Up to this writing (November 1980) the USSR has launched and recovered 3 Vostok biosats with Interkosmos, as well as French and American, experiments aboard. The flights were Kosmos 782, Kosmos 936 and Kosmos 1,129.

All biosat flights are preceded by a ground-based simulation in an identical replica of the spacecraft in which all factors of the flight, with the obvious exception of weightlessness, are reproduced. These simulations enable basic medical data to be gathered on the test subjects. During the actual flight a parallel 'flight' is conducted in the ground model with test subjects to determine changes brought about on the test animals by weightlessness. To ensure the only differences between the groups will be due to weightlessness the exact internal conditions of the flight craft are duplicated on the ground model.

Preliminary examination of recovered flight specimens is conducted at the recovery site in Kazakhstan in an inflateable hanger. Specimens are selected from the flight bunch, killed and dissected before they have adapted to Earth's gravity. The rest are dissected at 6 and 25 days after recovery.

For these flights Czechoslovakia has supplied vistar pure strain white rats as well as plants, isolated cells (tissue cultures),

Table 1. Interkosmos Satellites.

Type/IK	Launch date	Orbit (km)	Period	Incl (°)	Participants	Studies
3/IK 1	14 Oct 69	640-260	93.3	48.4	GDR, CSSR, USSR.	Solar short wave emissions, upper atmosphere parameters
1/IK 2	25 Dec 69	1200-206	98.5	48.4	GDR, USSR, CSSR, BPR.	Upper atmosphere, electron and ion densities.
2/IK 3	7 Aug 70	1320-207	99.8	49	USSR, CSSR.	Particles and fields, radio wave propogation.
3/IK 4	14 Oct 70	668-263	93.6	48.4	GDR, CSSR, USSR.	As IK 1.
2/IK 5	2 Dec 71	1200-205	98.5	48.4	USSR, CSSR.	As IK 3.
Vostok/ IK 6	7 Apr 72	256-203	89	51.8	HPR, MPR, PPR, CSSR, USSR, RPR.	High energy cosmic rays and micro-meteorites.
3/IK 7	30 Jun 72	568-267	92.6	48.4	CDR, CSSR, USSR.	As IK 1.
1/IK 8	1 Dec 72	679-214	93.2	71	BPR, GDR, USSR, CSSR.	As IK 2. But at higher latitudes.
2/IK 9 (Kopernik-500)	19 Apr 73	1551-202	102.2	48.5	PPR, USSR.	Ionospheric characteristics.
2/IK 10	30 Oct 73	1477-265	102	74	GDR, USSR, CSSR.	Particles and fields. Also as IK 3.
3/IK 11	17 May 74	526-484	94.5	50.7	GDR, CSSR, USSR.	As IK 1.
2/IK 12	31 Oct 74	708-264	94.1	74.1	BPR, GDR, HPR, RPR, CSSR, USSR.	As IK 3.
2/IK 13	27 Mar 75	1689-284	104.9	82.9	CSSR, BPR, HPR, USSR.	As IK 3.
3/IK 00	3 Jun 75	— - —	—	—	USSR, SWEDEN.	Solar studies, failed to reach orbit (see IK 16).
2/IK 14	11 Dec 75	1684-335	105.3	73.9	CSSR, USSR.	As IK 3.
AUOS/IK 15	19 Jun 76	518-484	94.6	74	USSR, CSSR, GDR, HPR, PPR.	Test vehicle for new series.
3/IK 16	27 Jul 76	517-464	94.4	50.6	USSR, SWEDEN.	Solar studies.
AUOS/IK 17	24 Sep 77	519-468	94.4	83	CSSR, USSR, HPR, RPR.	Magnetospheric studies.
AUOS/IK 18 (magion)	24 Oct 78	768-407	96.4	83	CSSR, USSR, GDR, HPR, PPR, RPR.	Magnetospheric studies.
AUOS/IK 19	27 Feb 79	996-502	99.8	74	BPR, HPR, PPR, CSSR, USSR.	Magnetospheric studies in conjunction with IK 18.
AUOS/IK 20 (OKEAN)	1 Nov 79	523-467	94.4	74	HPR, GDR, RPR, USSR.	Ocean dynamics studies.

bacteriological cells, fruit flies and lower fungi. Samples are also prepared in the USSR. A centrifuge has been carried aboard the satellites to create artificial gravity for some members of the space zoo.

The Kosmos 1129 biosat carried 38 white rats and 60 fertile Japanese quail eggs as part of the CSSR Incubator experiment to study the effects of weightlessness on the development of bird foetus'. Another CSSR instrument, the Kathermometer, studied the cooling properties of subjects. The male and female rats aboard were expected to mate and breed after a few days of flight; the embryos were expected to begin development on day 8. The USA supplied radiation dosimeters as well as bacteria innoculated carrots to study growth characteristics of bacterial tumors in weightlessness.

Examination of the flight animals showed no pathological changes in them compared to the ground-based group. Any changes were comparable to those of the control group with the flight animals taking just as long to adapt to light changes and embryo development did not appear to have been influenced by weightlessness. No effect was noted on the flowering or

Log of Vertikal Launches

Vertikal	Launch Date	Time (GMT)	Max. Height	Separated	Rocket
1	28.1170	0630	487 km	—	V-5-V
2	20.08.71	0400	463 km	—	V-5-V
3	02.09.75	0540	502 km	—	V-5-V
4	14.10.76	1150	1512 km	—	SS-5
5	30.08.77		500 km	100 km	SS-5
6	25.10.77	1215	1500 km	173 km	SS-5
7	03.11.78	1205	1500 km	175 km	SS-5
8	26.09.79	0320	505 km	100 km	SS-5

All launches were from the Kapustin Yar (Volgograd Station) launch site.

seeding of flowers and plants (this finding seems at odds with the results of the Salyut 6 biological experiments).

The French-made Bioblock 1 and 2 instruments showed the effects of heavy cosmic ray nuclei on unicellular organisms and plant seeds. On the Salyut 6-based Cytos experiment a stimulation of cell division by weightlessness had been demonstrated.

Further Flights

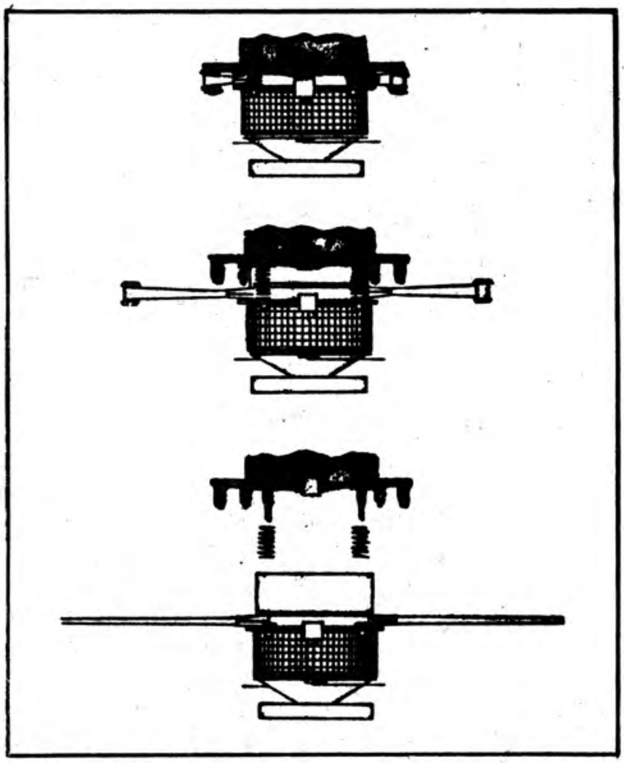
Future flights of the biosat programme are scheduled for 1981, 1983 and 1985. Three rhesus monkeys will be included on the 1981 flight (to prove the concept) with larger monkeys being flown in 1983. Details of the 1985 flight are not yet available. American experiments in 1981 will include the study of the primates' biorythms and cardiovascular systems. CNES, the French space agency, is also involved in the preparation of flight experiments. The French experimental devices Blood Current 1 and 2 are to be used to study blood circulation and cerebral circulation.

Vertikal Sounding Rockets

Since 1970 the CMEA countries have been cooperating in experiments carried to great altitudes by rockets of the Vertikal series. Vertikals 1, 2, 3 used the 1950s-developed V-5-V sounding rockets while Vertikal 4 began the use of the SS-5 Skean missile which has been used since.

In the latest flight, Vertikal 8, the short-wave emissions from the Sun were observed via TV. A high-altitude probe separated from the rocket during the ascent, at 100 km, and a separate recoverable container with the results and instruments separated from the probe at an altitude of 95 km (this container weighed 100 to 150 kg) and landed under a large parachute.

The Soviets have expressed concern over the amount of time it has taken in the past to assess the results from Vertikal probes (often up to 2 years) and much thought is now being given to decentralising the data dissemination, i.e. sending the data directly to the institutes concerned instead of routing it through a central bureau, a technique also under consideration for Earth resources data.



Ejection of the Radio 2/Iskara 4A combination from its carrier rocket. *Teknika-Moldezhi.*

Other Areas of Cooperation

In other areas of the Soviet space programme Interkosmos involvement is evident. Some highlights are detailed below:

- The Sun-synchronous Meteor/Nature satellites which have Earth resources roles have carried Infrared Fourier Spectrometers made in the GDR;
- The Prognoz Solar Automatic Orbital Station series has carried French UV astronomy experiments called Galaktika 1 and 2. The next Prognoz, number 8, will carry a Swedish Promiks 2 mass spectrometer to investigate high energy cosmic rays. Prognoz 8 will have 2/3rds of its instrumentation (by weight) built in the CSSR;
- The Mars Automatic Interplanetary Stations have carried French solar wind experiments called Stereo;
- The Meteor-type satellite Bulgaria 1300 (to be launched in 1981) will feature 2½ times the carrying capacity and 3 times the life of previous versions. 12 instruments manufactured in the BPR will study the ionosphere;
- The AUOS-T/Arcad 3 Soviet/French satellite (to be launched in mid-1981) will study the magnetosphere with about 100 kg of French-made instrumentation;
- The Radio 1 and Radio 2 satellites (launched along with Kosmos 1045 on an SS-9 'F' booster from Plesetsk in October 1978) were used by amateur radio operators around the world. The two 40 kg satellites were built by Soviet students and were operational for just over one year before they were disabled due to excessive radiation problems encountered during the launch phase. Replacement satellites, expected to have been launched in spring 1980, had not materialised at this writing;
- The Soviet 1984 Venera Automatic Interplanetary Station will carry 2 French balloons 3 to 6 metres in diameter which will float in the Venusian atmosphere for several hours. The same Venera spacecraft which delivers the balloons will later be used to image Halley's Comet in 1986. The French are studying participation in this portion of the flight, where the closest approach to the comet will be about 10,000 km. The 1984 mission also envisions the flight of a second Venera orbiter/lander combination.

VOLKSROCKET X-3

A LOW-COST MANNED SPACE PROJECT

Introduction

If all goes well it may not be too long before the first private astronaut is ready to fly. The plan follows careful preparations by Robert Truax, the veteran American rocket engineer, who set himself the task of producing a single-stage man-carrying rocket which would ascent 50 miles (80 km). He calls the rocket the "Volksrocket" X-3, or Arriba One. It is scheduled to lift-off from the edge of Fremont Airport near San Francisco Bay.

Last summer Truax successfully completed a static firing of the X-3 prototype at the chosen launch site. The test lasted 1 minute - the scheduled duration of the 4 Volksrocket LR101 NA-3 engines during operational flight. The engines developed a peak thrust of about 1.8 tonnes.

The following is a brief account of the project by Truax Engineering Incorporated (TEI).

The Objective

It is well known that space projects, especially those concerning manned flight, are extremely expensive. The expense is so great as to place such activities beyond the reach of the less affluent nations of the world, and completely outside the reach of private financing.

This report presents a project to put a man or woman far enough out into space to qualify that person as an astronaut. The cost is low enough to be within the reach of private financing, and could be defrayed by revenue from such sources as advertisers, closed circuit television, movie rights, etc.

The project is an outgrowth of Evel Knievel's Snake River Canyon jump. Truax Engineering, Inc. built the vehicles for that attempt. The project was conceived originally to satisfy Knievel's request for a feat to top the canyon jump.

The current high cost of manned space flight is attributable in a very large measure to the insistence by the National Aeronautics and Space Administration on very high probability of success. The 98% survival and 96% mission success goals were not set by the astronauts out of consideration for their own safety. To a man, they would have accepted much lower assurance. The figures were set by administrators through fear of failure in the wake of the Vanguard project.

The escalation of cost with reliability assurance is extremely rapid. Although it is not possible to quantify the increase rigorously, we all recognize that it would require an infinite amount of money to obtain 100% reliability, even with a simple device. It is not at all unreasonable to expect that an improvement in reliability from 90% to 98% would increase the cost by a factor of ten.

Mr. Truax, President of Truax Engineering, Inc., has been a pioneer in the application of cost-effectiveness techniques to space flight. He delivered the first technical paper ever presented on the subject, and in 1965 headed the recoverable launch vehicle study sponsored by the *American Institute for Aeronautics and Astronautics*. This study was instrumental in convincing the NASA to initiate the Space Shuttle proramme.

We expect to achieve the extremely low cost by rigorous adherence to a minimal objective, by strict simplicity of equipment, by extensive use of well proven but surplus components, and quite frankly, by asking the astronaut and the sponsors to take a somewhat higher risk than is currently acceptable to the U.S. National Aeronautics and Space Administration. An outline of the rocket appears in Figure 1.

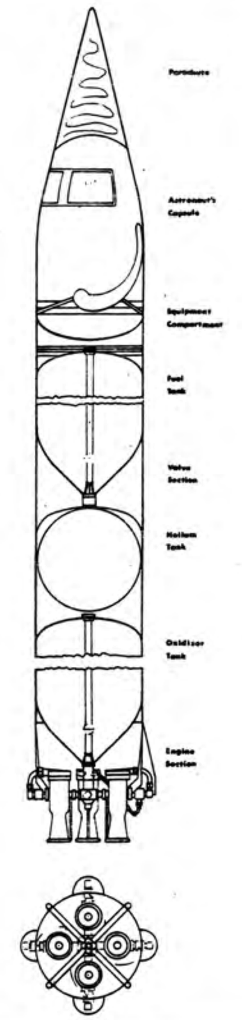


Fig. 1. General layout of the Volksrocket.

DESIGN STUDY RESULTS

Scope

This section assesses the technical feasibility of building a rocket capable of taking one man to an altitude in excess of 50 miles, and returning both rocket and occupant to Earth safely, while adhering to very severe cost constraints.

The flight will be sub-orbital, with a near vertical trajectory. The 50 miles altitude was set because it represents the officially adjudicated altitude that constitutes the beginning of "outer space." People entering the regime above qualify for the title of "astronaut."

Performance

Performance calculations were made covering a range of lift-off weights from 2,200 to 3,100 lb. and for two thrust levels. The latter were selected to conform to the two thrust levels at which the engines normally operate when used on the Atlas missiles, namely 830 lb. and 1,000 lb. each, for totals of 3,320 and 4,000 lb. respectively. Lift-off weight was limited to 3,100 lb. because that figure gives a thrust-to-weight ratio of about 1.3 This value is close to the lower limit of conventional practice. Some studies were made of higher weights, down to a T/W ratio of 1.1, and additional altitude resulted, but the lower initial acceleration might give excessive side drift on a windy takeoff. Further consideration should be given to higher lift-off weights before final design.

Figure 2 is a plot of the peak altitude as a function of burnout weight for a lift-off weight of 3,100 lb. It may be seen that the former must be kept under 1,146 lb. in order to reach the

required altitude. Achieving this weight goal was the primary objective of the design effort.

Powered Flight
The rocket starts from a vertical position on the launch pad. A centrally located hold back restrains the rocket until full thrust has been reached. The rocket lifts off as a thrust-to-weight ratio of 1.3. Maximum dynamic pressure is reached at about 30,000 ft after 60 seconds of powered flight. Burnout is at 113,000 ft, 100 seconds after lift off. A maximum velocity of 3,300 ft/sec is reached at this point.

Free Fall
The rocket coasts with diminishing speed to an apogee substantially in excess of 50 miles, after which it falls with increasing speed, reaching nearly 3,300 ft/sec again about the time of drogue deployment. Throughout the flight, the rocket will be tracked by an AN/MPQ-10 radar used in conjuction with a transponder in the rocket.

Descent and Recovery
The entire rocket will be recovered intact by parachute. On descent, somewhere between 100,000 and 150,000 ft, a small drogue chute will open stabilizing the rocket in a tail-down attitude. This same parachute will gradually slow the rocket from some 3300 ft/sec. to about 150 ft/sec. by the time the vehicle has descended to an altitude of 20,000 ft. At this altitude, after about five minutes of flight, the main canopy will be deployed, reducing the rate of descent to about 65 ft/sec. The increasing atmospheric density will slow this rate to about 45 ft/sec. on splashdown, which will take place about 6 minutes later. No injury to the astronaut or to the rocket is anticipated at this speed.

A 125 ft cutter, with a helicopter platform built on the stern, will be at the expected point of touchdown. The recovery helicopter will be vectored to the point of impact predicted from radar tracking data. The rocket will be equipped with a localizer beacon and dye marker to assist in final pinpointing. The helicopter will carry two frogmen and a hoist. The frogmen will jump from the helicopter, attach a hoisting sling to the rocket, and the helicopter will transport the rocket, with the astronaut still inside, to the launch area, where the capsule will be opened and the astronaut allowed to come out.

Table 1. Principal Characteristics Space Cycle X-3

Weights (lb)	
Lift off	3,100
Burn out	1,100
Dry empty weight	759
Payload	190
Dimensions	
Length O/A	24.2ft
Diameter	25in.
Performance	
Peak altitude	286,000 ft.
Burnout altitude	120,000 ft.
Burnout velocity	3,300 ft/sec
Design features	
Propulsion:	Liquid propellant rocket; RP-1 and LO_2 propellants. Pressure-fed system using stored helium gas; four Rocketdyne LR101-NA3 engines.
Stabilization:	Autopilot operating pivoted engines. Vertical take off - no launch rail.
Recovery:	4-stage parachute system.

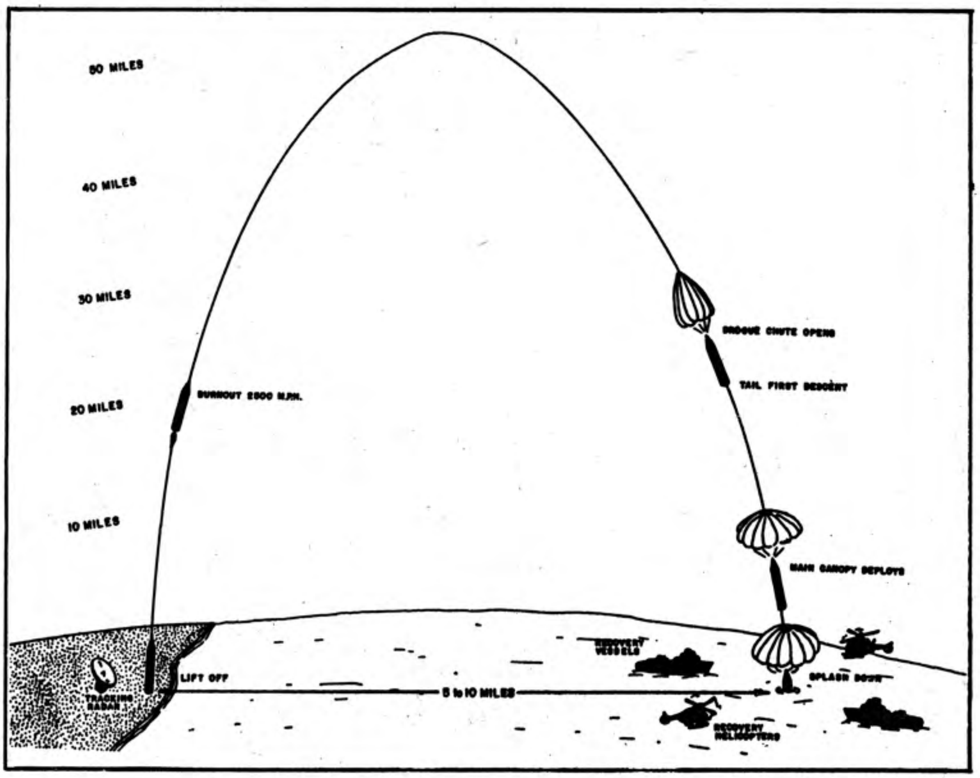


Fig. 2. Proposed flight plan for the rocket.

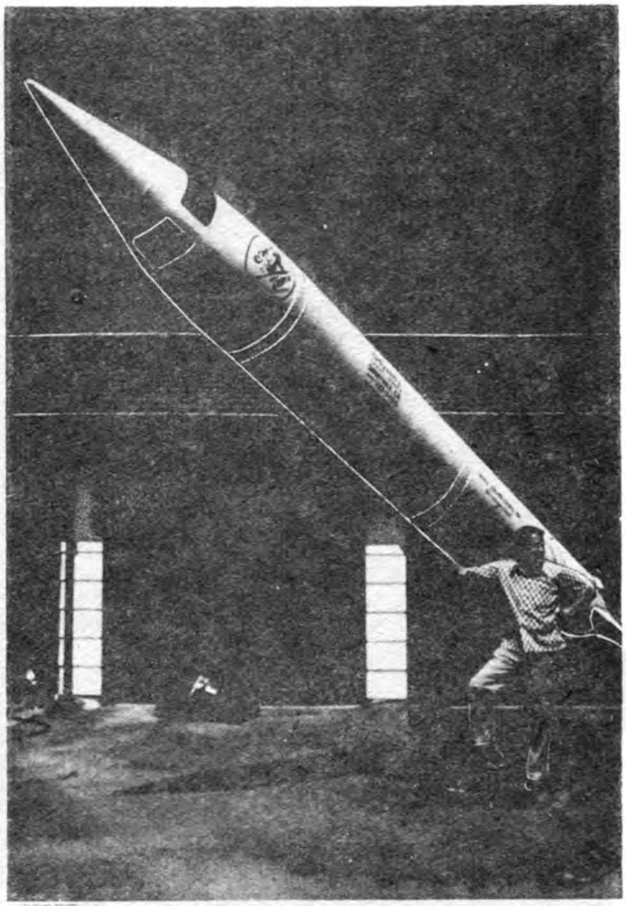


Fig. 3. The Volksrocket and its designer, Robert Truax.
Courtesy Robert Truax.

FUTURE POSSIBILITIES

If the advertising and "show biz" aspects of the first flight are able to produce sufficient revenue to pay the development costs for the rocket and perhaps show a profit for the investors, it is our plan, after making a number of additional unmanned flights, to further prove the reliability of the rocket, to open the "barnstorming" era of space flight by selling rides out into space to anyone having a yen to see our beautiful Earth from out there. We currently estimate the price of a ticket at less than ten thousand dollars. A high price, perhaps, but it would be the experience of a lifetime.

In addition to its man-carrying capabilities, the X-3 may see use as a recoverable sounding rocket, at a lower cost per flight than any other rocket of comparable performance.

Still further in the future, adding a second stage might permit attaining orbital velocities.

COST

The overall programme cost is estimated to be $875,725, broken down as follows:

Investment to August 1980	
Design and construction of prototype	$ 75,000
Procurement of components	5,000
Completion of prototype	
Autopilot design and development	10,000
Procurement and installation of remaining components	8,000
Construction of two flight vehicles	350,000
Bench and field testing	
20 propulsion tests	80,000
2 parachute drop tests	12,000
Lease and preparation of launch equipment	16,500
Rework as a result of testing	75,000
Launch services	
Launch crew (3 vehicles)	45,000
Recovery ships, planes and helicopters	85,000
	761,500
TEI profit (15%)	114,225
	875,725

The primary basis for costing construction of the flight vehicles is our experience with the Skycycle X-2s. The total costs for the design, construction, testing and launch for two vehicles was $150,000. The X-3 space shuttle is somewhat more complex, having perhaps twice the parts count. This added complexity, plus an inflation adjustment, leads to the cost shown.

The cost estimate for the propulsion testing is based on experience in the testing done to date, modified for the additional propellant cost for full duration runs with all four thrust chambers firing.

Cost of launch services is based on an estimate by Western Aviation Enterprises, Inc.

No cost has been included for lease of the launch site, since it could range from zero up depending on the location.

All bench testing, except that done by the original manufacturer, will be done by T.E.I. Captive firing tests will be done at the T.E.I. facility in Sacramento. Drop testing, to verify parachute performance, will be done by Western Aviation Enterprises of Santa Rosa, California under T.E.I. supervision.

Typical tests will include:

1. Hydrostatic tests of all pressure vessels.
2. Leak and pressure testing of all tubing assemblies.
3. Water flow calibration of hydraulic components.
4. Load testing of all structural elements.
5. Leak testing of astronaut's capsule.
6. Calibration firing of each thrust chamber.
7. About 20 captive firing tests of the all up propulsion system.
8. Open and closed loop testing of the autopilot.
9. Air drop tests of the complete prototype rocket to test parachute functioning, water landing and develop recovery techniques.

Table 2. LR101 NA-3 Engine Specifications

Rated Thrust	1,100 lb.
Propellant Flow	
Oxidizer	3.21
Fuel	1.74
Feed Pressures	
Oxidizer	575 lb/in^2
Fuel	575 lb/in^2
Combustion chamber pressure	364 lb/in^2
Nozzle throat area	2.01 in^2
Nozzle exit area	11.76
Expansion ratio	5.85
Characteristic velocity	5,000 ft/s
Specific impulse (sea level)	202
Oxidizer density	70.7 lb/ft^3
Fuel density	50.5 lb/ft^3

Almost all of the required instrumentation is on hand. Truax Engineering, Inc. has available the following major items of test equipment:

1. One CEC-36 channel oscillograph.
2. Two Midwestern 50 channel oscillographs.
3. Two 8 channel Brush recorders.
4. One Textronix dual beam oscilloscope.
5. One 3-axes gyro test table.
6. Two 50-gal. liquid oxygen tanks.
7. Two static test stands (for engine firing).
8. Force and pressure measurement standards.
9. Numerous transducers for temperature, pressure, flow, linear motion, force, etc.

The launch site has not yet been selected. The area of San Francisco Bay was the prime choice at the time of preparing this article. Since the sponsor(s) may have strong preference for one location or another. Since recovery is to be in the water, a coastline site, or a site near a sizable body of water is required. Site requirements are minimal as far as the technical operations are concerned. The rocket and all required launch support equipment are mobile, and will be housed in three vans, one purchased and two leased.

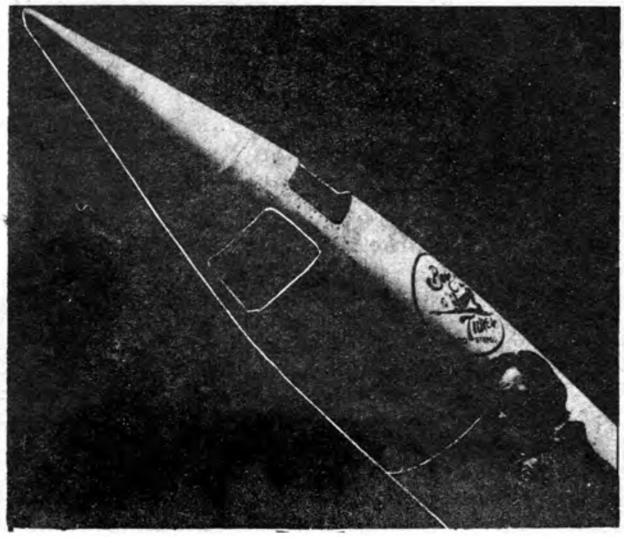


Fig. 4. Candidate astronaut Martin Yahn.

Courtesy Robert Truax.

INDUSTRIAL DESIGN IN SPACE

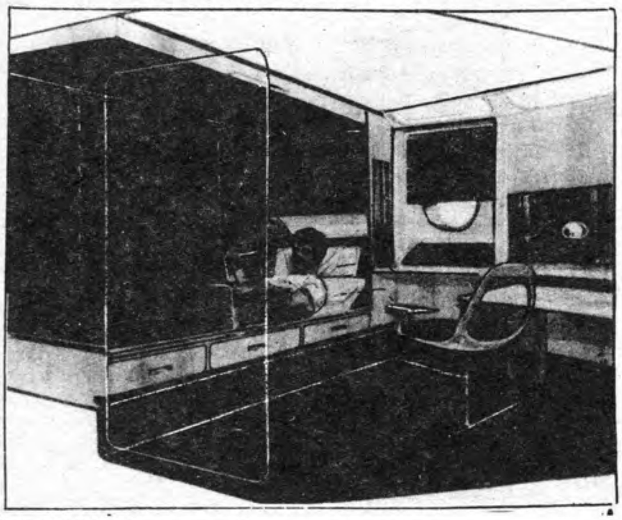
By Dave Dooling

If It's Sleek, And Floats, Chugs, Drives or Orbits (Among Other Things) Think Raymond Loewy

That headline from a Washington paper in early 1975 seems to best summarize the impact that the famed industrial designer. Although ordinarily he might not be grouped with Leonardo da Vinci, Loewy's designs have had as far-reaching an impact on the way we change our living and working environments.

Since arriving in New York in 1919 with only a few dollars in his French lieutenant's uniform, he has redesigned corporate logos (including the unforgettable double-X in Exxon), both bottle and fountain for Coca-Cola, the Studebaker and Avanti automobiles, sewing and mimeoraph machines, railroads and ferry boats.

And the interior of America's first space station.



Loewy design for space station crew quarters.

Loewy's life and work are displayed in a new book, *Industrial Design* (250 pages, 10 and three-eighths inches square, 700 illustrations, $45), released by the Overlook Press through Viking Press in New York. The portion relating to his space work covers only a dozen or so pages.

Loewy's interest in space started long before the 1960's. For Chrysler at the 1939 New York World's Fair, he designed "an animated, relistic model of a rocket-launching spacecraft installation .... as an expression of the corporation's long-range vision and technological leadership."

That vision was truer than he expected: Chrysler built the Redstone rocket that (modified) launched America's first satellite and the Saturn IB first stages that started astronauts on their journey to Skylab.

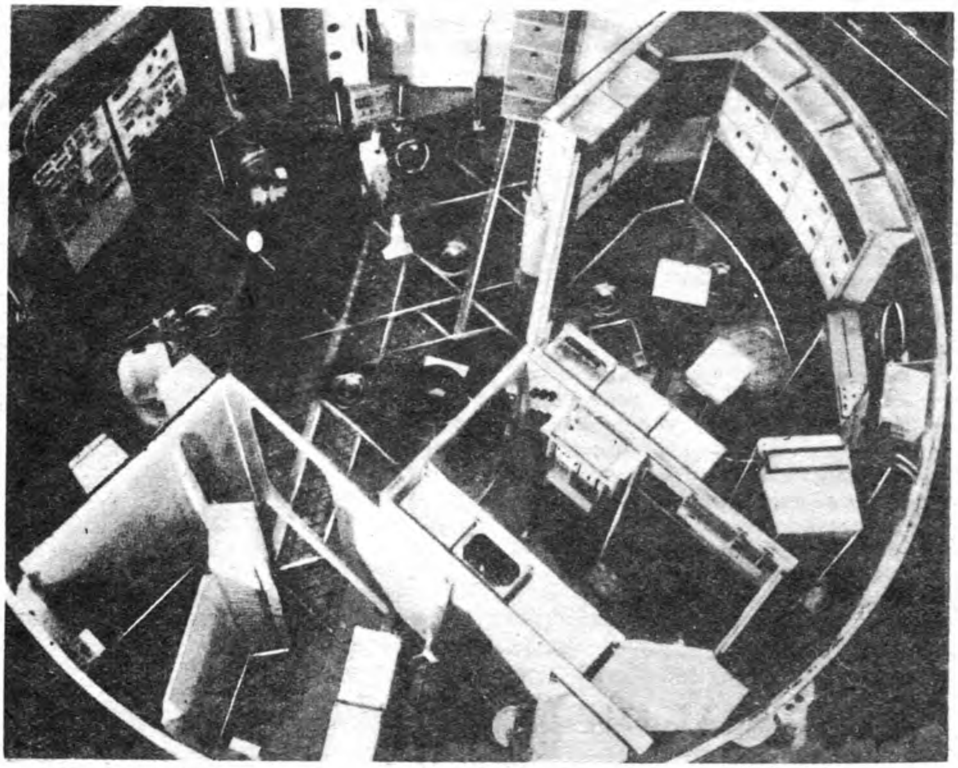
In 1956, he proposed a satellite called the "Star of Hope," which would have lights at each end to blink to the world, in Morse code, "Peace on Earth, good will to men." Then Senator Lyndon Johnson liked the idea and proposed it to Congress.

Loewy recalls that his association with NASA came about through his redesign - inside and out - of Air Force One for President Kennedy. On one of his visits to the White House Loewy was introduced to NASA Administrator James Webb, a meeting that "later led to the most important assignment of my life."

That feeling is reflected in the cover of his book: it shows Loewy standing in the Skylab wardroom.

"He's a real afficiando of space," Robert Lovelett of NASA said of Loewy's reasons for offering assistance. "He's also very patriotic. He's done a lot of government work," including redesign of warship interiors, some of it classified. Lovelett, a NASA engineer who worked with Loewy, was interviewed in 1975, two years before his death.

Interior designs and space travel once seemed mutually exclusive, but the nine crewmen who lived aboard Skylab for



Interior of the Skylab space station, showing the influence of Loewy. The wardroom is at upper right, with the sleeping quarters at the bottom of the picture.

up to three months say that such considerations made success possible.

Perhaps the best commendation came from astronaut Jack Lousma who spent 28 days aboard Skylab and wrote to Loewy that, "We found it a most habitable home," and recommended that future spacecraft have larger, bubble windows.

The first manned spacecraft literally had no room for interior appointments. Mercury was so small that its lone astronaut almost had to wear it as much as fly in it. The two-man Gemini and three-man Apollo spacecraft were little better. While crew safety was of paramount importance, crew comfort was left in the van that took them to the launch pad.

The idea was that for a brief space mission, the crew should be willing to put up with anything (astronaut Mike Collins wrote that you would put up with the most obnoxious person simply to fly, somewhat like a camping trip.

With Skylab, things could be different, but almost were not. Skylab used an empty rocket stage, 22 feet wide and 58 feet long, as crew quarters and workshop. Lofted by a Saturn V rocket, it had more room than previous spacecraft.

In the mid 1960s, when it was still taking shape as the Apollo Applications Program, NASA managers started to worry about how long dedication could last in a home designed by mechanics, Lovelett said.

"After the initial design of Skylab a number of our upper managers felt that there was a lack of humanism in the design - specificially Dr. (George) Mueller, then associate administrator for manned space flight," he said.

"He kept making the comment, 'Why don't you have an armchair, why don't you have something that is human in nature?' which was surprising because Dr. Mueller himself had a reputation as being cold, very efficient.

"And about the same time, Mr. Loewy approached the agency and said 'I'd like to have a role in the space programme.' So it just seemed very natural to bring him onboard, as he put it himself, as a consultant on the interior design of Skylab."

When they started their work in 1967, Loewy and assistant, Fred Toerge, visited space centres and factories. At Marshall Space Flight Center in Huntsville, they put on spacesuits and went through the motions of being an astronaut, "a valuable lesson for our later conceptual efforts" Loewy wrote. But what they saw in those mockups must have appalled them.

"Some of the things that they really objected to when they first looked at the laboratory - and they looked at Skylab in a mockup stage - was a uniform dark colour throughout." Lovelett said. 'All the colours were the greenish colour you see in interior aircraft structure. There was exposed mylar insulation which floated in the air flow."

The initial design for Skylab called for it to be used as a rocket stage launched with a Saturn IB, then outfitted in orbit by the crew. In 1969, the design was changed to a "dry workshop" outfitted on the ground and launched by a Saturn V.

The problem was that the engineers who laid out the interior did it almsot as an extension of the control panels.

"The space programme is dominated by people with engineering backgrounds and a substantial amount of experience in cockpit design," Lovelett explained. "There's an entirely different set of thinking involved in the very functional design of a cockpit than there is when you design a habitat where you're going to live for days or weeks or months."

Toerge and Charles O'Donnell, another Loewy designer, summed up their feelings in a 1970 paper for the American Astronautical Society:

"Mental attitudes change from profession to profession, and it is an important difference whether man is conceived an an extension of the machine, or conversely whether the machine is an extension of man .....

"We are no longer concerned with the primitive existence (of man in space), but with a selective environment conducive to supporting his ability to adapt to the more difficult problems of isolation, sensory deprivation, social interactions and imposed stress."

Loewy wrote that the task of designing Skylab left him "a bit staggered," but he accepted instantly, although not everyone welcomed Loewy's presence.

"At the outset I encountered resistance from NASA

engineers and astronauts concerning the philosophy of design for lengthy space missions," Loewy wrote.

What followed was a redesign so complete that only the shape of the rocket stage left the impression that it was the same space station.

"They did a lot of work on the personal hygiene area," Lovelett said. "They changed the design quite extensively. A lot of work went into that toilet design," which had to be useable yet airtight.

"They did a lot of work in the kitchen area in making access to the table more convenient," he added. Loewy said he chose the triangular design because, "I was opposed to preferential hierarchal treatment for crew members during long missions.'

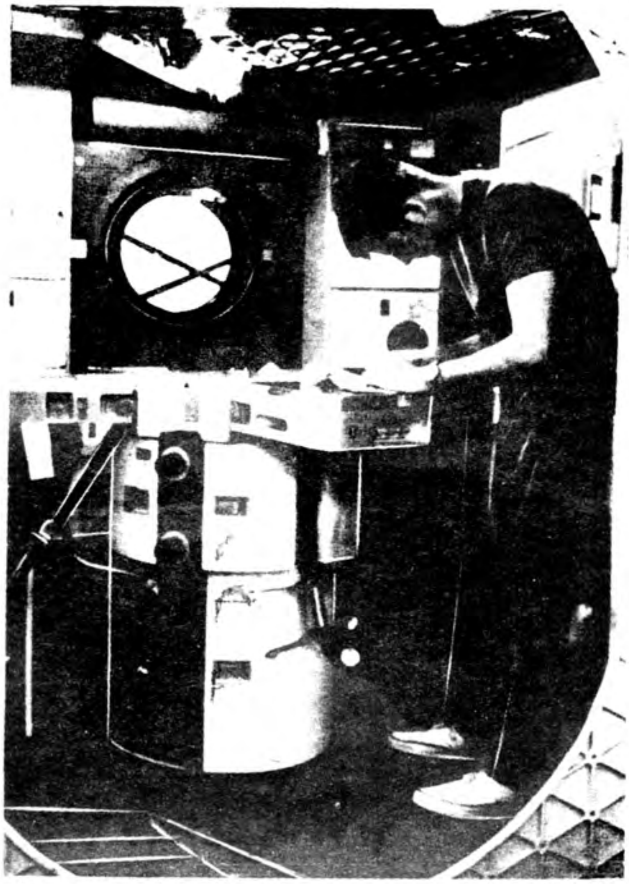
The window, too, was his idea, but it was not accepted without resistance. Rocket stages are designed to take loads in a certain way, and putting a hole through a tank wall means a major weak point in carrying those loads. Engineers were opposed to having a window just for the crew to look through while eating, although two smaller holes were made for scientific airlocks.

With the support of astronauts Lousma and Paul Weitz, Loewy and Mueller prevailed.

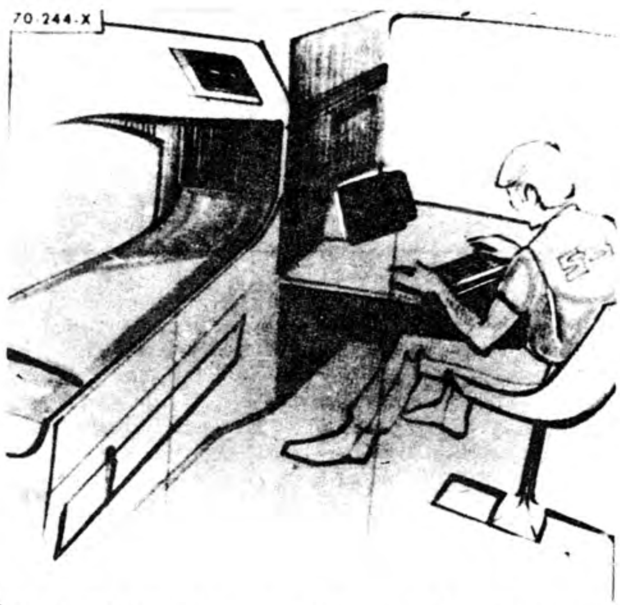
"I stated that I could not fully endorse a capsule in which there would be no possibility for months at a time to look out and see our Earth," Loewy wrote. "All the Skylab crews during debriefing stated that without the porthole the mission might have been aborted."

It also came in handy for taking photographs of interesting terrain and weather as they passed quickly below.

Intangible changes included practical recommendations that each crewman be allowed eight hours a day to him self, that they eat meals facing each other, and that all surfaces be smooth to make clean-up easier after space sickness.



Skylab 2 astronaut Joe Kerwin works in the wardroom during a training session in the 1g simulator.



A Loewy design for crew quaters in a space station, somewhat more luxurious than the functional Skylab.

For various reasons, Skylab's interior was not exactly as Loewy redesigned it.

"Not too much of Loewy's designs were directly accepted," Lovelett said. "However, they influenced what was actually used in Skylab. They influenced the design of the food trays, the colours inside, the sleep stations. But still, they never became the way an industrial designer would see them . . . . .Their impact was more implicit than direct."

He continued that Loewy brought to the surface many desires that had been felt but went unexpressed for various reasons .

" People tend to think of our astronauts as stoics, hardened in nature. Yet they do like something like this (humane design). "he said. "If they do want something, there's no way they can suface this. If they say, 'I want a chair,' it appears they're not really stoic, so they really can't surface it themselves."

Loewy's design probably will continue to be felt during the Space Shuttle progr amme. He conducted habitability studies on the Shuttle while it still had a two-s tage, fully reusable design, and on the space station programme which was later abandoned.

Lovelett noted that there are few creature comforts aboard the Shuttle and Spacelab, a science workshop it will carry, but that is because of the small size and relatively short missions (mostly a week with a few up to four weeks).

But with Marshall's 25-kilowatt power module, the Shuttle will be able to stay up to three months, and already preliminary designs are being drawn up for modules to handle the longer stays.

"I'm positive some of the ideas they put forward will carry into Shuttle for the simple reason that the engineer he worked with at Johnson Space Center is responsible for the interior design of the Shuttles," Lovelett added.

HALLEY'S COMET MISSION

The European Space Agency (ESA) has selected British Aerospace Dynamics Group Space & Communications Division to head development of the Giotto space probe which will intercept Halley's Comet in 1985/86. The work will be led by the Division's Bristol factory.

ESA's Industrial Policy Committee agreed that direct negotiations should start with British Aerospace. This decision is a result of the highly successful GEOS-1 and -2 satellites upon which the design of GIOTTO is based. The total value of the contract will be about £27 million shared between European aerospace companies.

Halley's Comet which is visible from Earth every 76 years, will make its next appearance in 1985/86. The object of Giotto will be to intercept the Comet with a variety of scientific instruments. These are expected to provide data on the chemical composition of the "coma" region surrounding the nucleus, and of the tail of the comet. A camera will take pictures of the comet's nucleus and measurements may also be made of its magnetic field.

The time available for observation by Giotto is only a few hours, which places great importance on the reliability of the space probe and the accuracy of prediction of the orbits of probe and comet.

Halley's Comet made an appearance in 1301 and is believed to have been the model for the Comet depicted in the painting "The Adoration of the Magi" by Florentine master Giotto di Bondone. Probably completed in 1304 the painting can be considered as one of the first visual impressions of Halley's Comet recorded in history.

TRANSCONTINENTAL RADIO TELESCOPE

Astronomers at the California Institute of Technology and the Jet Propulsion Laboratory have completed a feasibility study of a nationwide array of large radio dishes that would, in effect, transform the United States into an immense radio telescope, writes Gerald L. Borrowman. It is claimed that the transcontinental radio telescope would be both economical and a powerful scientific tool, with thousands of times more resolving power than the largest optical telescope.

The system, which would be operated as a national facility, would also be "far superior" for Very Long Baseline Interferometry than the current *ad hoc* combination of radio telescopes now used in such studies.

The transcontinental radio telescope would produce the first high-quality fine radio maps of the structure of such exotic objects as quasars, forming and dying stars, and other celestial objects in our Galaxy and beyond. The system could also be used to make more precise measurements of astronomical distances and to study with much greater accuracy the Earth's rotation and tectonic plate movement.

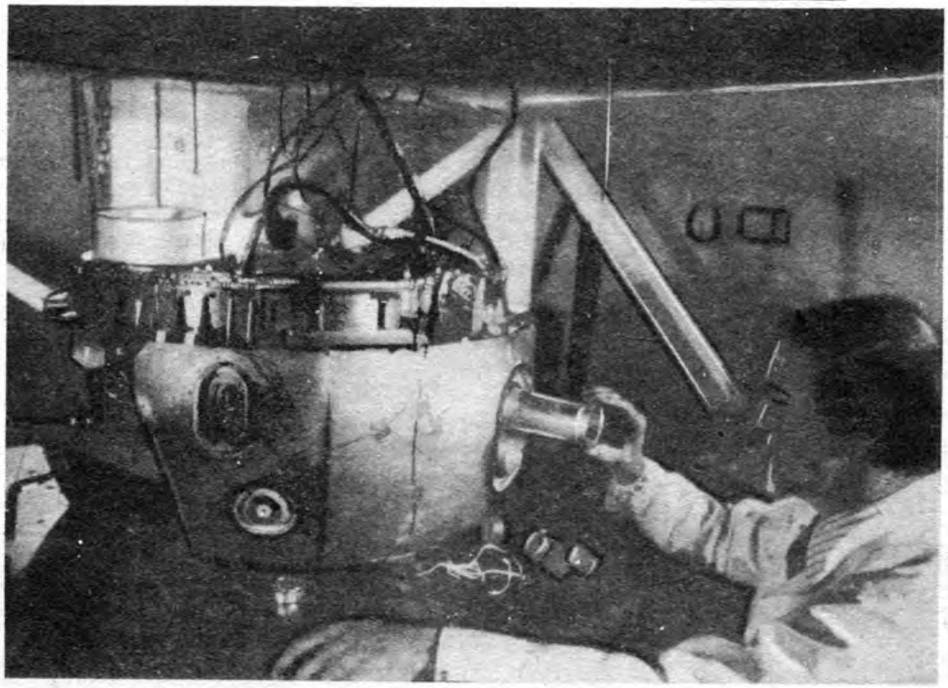
An array of ten matched radio dishes, each about 25 metres in diameter, could be constructed throughout the continental U.S. and in Alaska and Hawaii for about 38.8 million, say the researchers, who were led by Caltech Professor of Radio Astronomy, Marshall H. Cohen. Operating costs would run to 4.8 million per year, and the array would be controlled by a single computer at a central operations centre.

Since the 1960's, Very Long Baseline Interferometry has been used to give astronomers an unprecedented look at the structure of astronomical objects. By synchronizing observations using high precision atomic clocks, astronomers were able to correlate distant telescopes, and to produce the first crude radio maps of distant galaxies with violent active centres. The maps revealed such phenomena as massive jets of matter and energy spewing from the galactic cores.

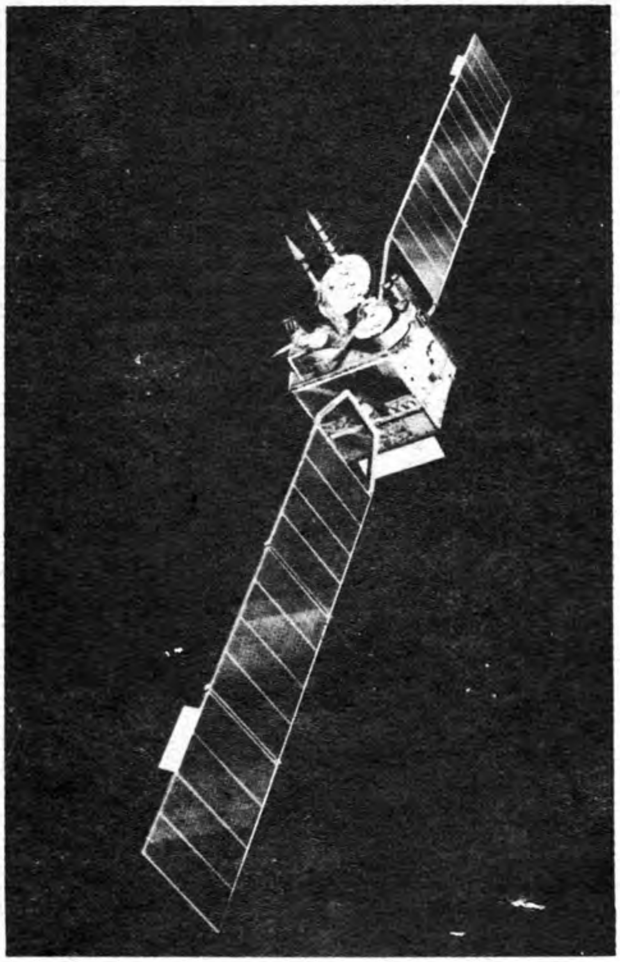
Using VLBI, they also were able to make precise studies of the Earth, by using distant quasars as fixed beacons to determine the relative movement of the radio telescopes. In this way, precise measurements of the Earth's rotation and of the movement of such crustal features as the San Andreas fault were made.

"VLBI is unmatched in angular resolution by any other astronomical technique," said the Caltech-JPL study. "In extragalactic astronomy it is the only tool available for determining the structure of the energy source in quasars and active galaxies."

Because the individual VLBI radio dishes of the array would be so widely separated, it is possible to make such astronomical measurements trigonometrically, says the report, greatly



The atmospheric probe of the Galileo Jupiter spacecraft, due for launch in 1985 by the Shuttle. The capsule will separate from its carrier 100 days before Jupiter encounter and plunge through the atmosphere to take readings with its 7 experiments. It is expected to survive for about 2 hours before being destroyed by the pressure.



A military comsat designed by British Aerospace Dynamics Group to meet the UK's defence communications needs of the mid-1980's.

reducing current uncertainty about fundamentally important measures like the distances to stars, galaxies and other objects.

In addition, the VLBI array could test the theory of relativity by comparing theoretically predicted and actual measurements of the gravitational deflection of radio waves from stars by the Sun.

Radio telescopes throughout the world have already been joined in VLBI studies, and in the United States a group of seven existing dishes (in Massachusetts, West Virginia, Iowa, Texas and California) have been involved in such studies since 1975.

IMPROVED SHUTTLE TANK

Assembly of the Space Shuttle's first lightweight external propellant tank began last December at the Marshall Space Flight Center's Michoud Assembly Facility in New Orleans. Work began with the precision trimming and welding of aluminium gore segments to form the aft dome of the liquid hydrogen tank. The first lightweight tank is expected to be completed and ready for delivery in the summer of 1982, in time to support the Space Shuttle's fifth launch.

The modified tank will be 6,000 lb (2,721 kg) lighter than its predecessor, and will therefore increase the Shuttle's payload-carrying capability by about the same amount.

To accomplish this weight reduction, the External Tank has been redesigned to incorporate the results of a recently completed structural test programme. This showed that it is possible to reduce the thickness of many of the aluminium skin panels without affecting the integrity of the tank.

Changes to the materials used in certain components have also been made to take advantage of recent developments in the metals field. And, the antigeyser line, used in the liquid oxygen fill system, is also being deleted.

The External Tank - actually two tanks connected by a collar-like intertank - carries the liquid hydrogen and liquid oxygen propellants for the Shuttle's three main engines. It is the only major element of the Shuttle that is not recovered for re-use.

The External Tank is being built by Martin Marietta Aerospace, Denver Division, under contract to the Marshall Center.

NASA AWARDS

Two engineers at NASA's Jet Propulsion Laboratory have been honoured for their contribution to the precise navigation of spacecraft and to the confirmation of the validity of predictions of Einstein's Theory of Relativity. Warren L. Martin and Dr. Richard M. Goldstein each received a NASA Certificate of Recognition and a $5,000 cash award.

The new technique, Binary Coded Sequential Acquisition Ranging System, was invented by the two engineers and increased the accuracy of determination of the distance from a fixed point on Earth to a spacecraft by 40 times.

The system provided the first confirmatory measurement of a relativistic prediction by using a spacecraft's radio signal to determine the effect of the Sun's gravitational field on the signal. Einstein predicted an infinitesimal reduction in the velocity of radiation passing through a large gravitational field, an effect so small that exact measurement would require an accuracy of 1 part in 4 billion. The new technique exceeded the accuracy requirement by 10 times and confirmed the prediction.

NEW ROYAL GREENWICH OBSERVATORY DIRECTOR

Professor Alexander Boksenberg is to succeed Professor Graham Smith as Director of the Royal Greenwich Observatory on 1 October. Professor Smith is to become Professor of Radio Astronomy at Manchester University and Director of the Nuffield Radio Astronomy Laboratories (Jodrell Bank).

Alec Boksenberg is regarded as an outstanding astronomer by his contemporaries. At the age of 44, he has been Professor of Physics at University College London's Department of Physics and Astronomy since 1978. In 1960, Alec Boksenberg joined UCL's Department of Physics and Astronomy and he has remained there since as, successively, research assistant, lecturer in physics, head of the ultraviolet and optical astronomy group, reader in physics and professor. He is currently an SRC Senior Fellow.

He was elected a Fellow of the Royal Society in 1978 and is a Fellow of the Royal Astronomical Society. He has served on many SRC working groups and panels, is currently chairman of the Council's Astronomy II committee (which has responsibility for infra-red, optical and ultraviolet observations from space and the ground) and a member of the Council's Astronomy Space and Radio Board.

PROJECT POSTAR

The aerospace company TRW has purchased a Shuttle Getaway Special' ticket and donated it to the Exploring Division of the Boy Scouts. The experiment finalists will be selected by a NASA-TRW panel.

SOCIETY NEWS

SPACE MUSEUMS

The preservation of objects from the early days of rocketry through to today is a topic which generates a good deal of passion among space enthusiasts. Members who attended a talk on "Space Museums" * by Drs. John Becklake and John Griffiths in the Golovine Conference Room at the Society's Headquarters were treated to a quick tour of some of the world's space displays and a description of the Science Museum's work in London.

In this country we have the less spectacular objects to preserve and display but in the US there is a plethora of material - apparently too much. Slides of various British and American displays showed a distinct difference between the two: ours tend to be small, not easily accessible and not visually orientated, whereas the Americans go for the "big-sell", visually stimulating exhibitions. This second approach is fine for the moment but remember that rockets and spacecraft were built to be used soon after manufacture - they were not designed for standing around over several decades. Many members will have seen the deteriorating conditions of rockets (Atlas, Titan, Saturn, Redstone, etc.) outside Patrick Air Force Base in Florida, at the Cape Canaveral Air Force Museum, the Visitor's Information Center at KSC and 'Tranquility Base' in Huntsville. The first three to suffer from the corrosive action of sea air and spray - a rare Atlas B test missile at Canaveral - will not survive in its already poor condition for much longer. The three remaining Saturn 5's are all kept in the open air, and a rare V-2 in Huntsville has to be patched up with fibre glass!

That said, the indoor collections at Huntsville and the National Air and Space Museum in Washington, D.C. are unrivalled for their impact. Who can forget the collection of Apollo Command Modules, Mercury and Gemini capsules and hordes of spacesuits? What a pity that we can get hold of only the Apollo 10 Common Module - even the Jackson Community College in Michigan has the real Apollo 9!

Other countries do not have space centres - even the US versions are not really *museums* but include astronautics exhibits. The USSR has three main exhibits at the Palace of Economic Affairs, the Polytechnical Museum in Moscow and the Tsiolkovsky museum in Kaluga. These are somewhat disappointing from a historical point of view although Tsiolkovsky's house is well maintained.

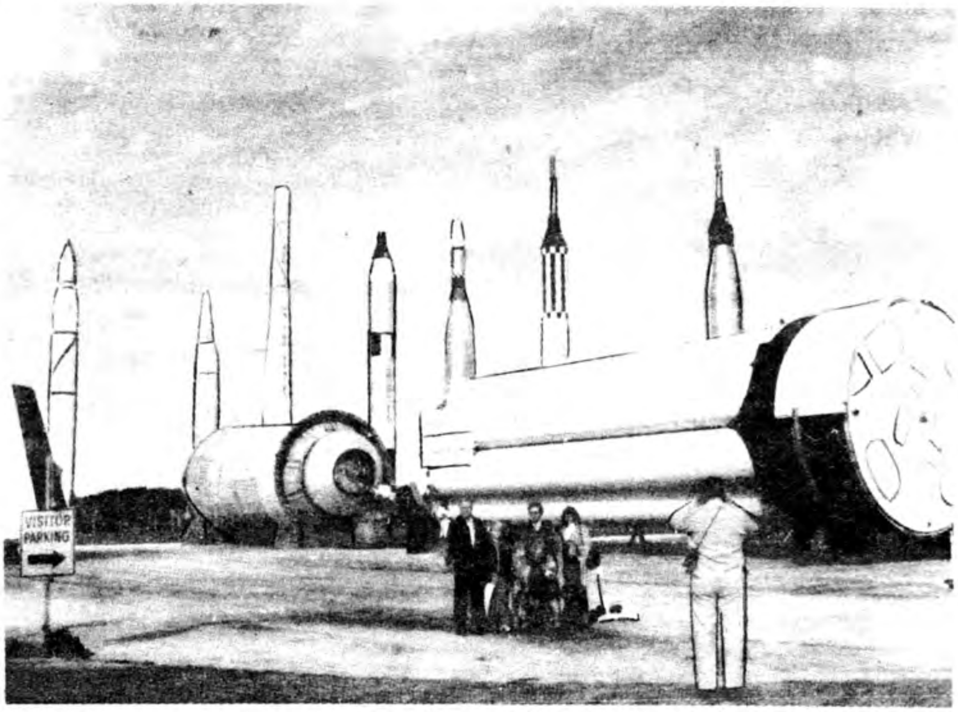
The Aviadome at Schipol Airport is small and privately owned but it does have a full-size Skylab mockup, a half-size Viking and Mercury and Gemini capsules. The Swiss Transport Museum in Lucerne also has Mercury and Gemini craft. European space objects are well represented at ESTEC, with its flight spares of European satellites and display cases on astronautics topics. In Paris (Le Bourget and the Palace of Discoveries) one can find French rockets and satellites and there is a possibility of a national science centre being built. Delft in Holland has a V-2 and German Second World War missiles: the Deutsche museum in West Germany has exhibits from the days of Max Valier.

Space displays in the UK

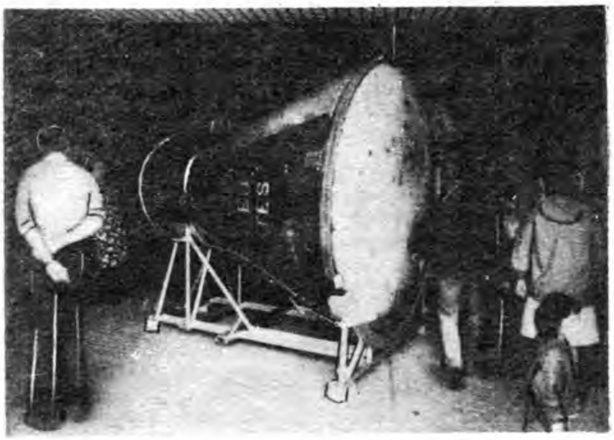
Closer to home, we have a few main centres and a number of small ones hidden away. Of the four main locations, the Science Museum is perhaps the best known but until the arrival of Dr. Becklake in 1972 the subject was somewhat neglected. (It often seems to be the case that space displays are created or upgraded by the efforts of one man - the Cape Canaveral Air Force Museum was begun by a serving officer asking if he could use objects left lying around).

The Museum's first contact with space was in 1945 with an exhibition of captured German weapons - including a V-2 - and the early 1960's saw Alan Shepard's *Freedom 7* Mercury capsules creating queues which stretched out of the building and down the road to the Geological Museum! The most famous exhibit of all is the Apollo 10 Command Module which came to rest in London after touring the country in 1971 (the writer well remembers the sight of schoolboys trying to 'acquire' pieces of it during its stay in a large tent near Sheffield). That area of the ground floor has since been turned into the 'Exploration' gallery and houses a full-scale mockup of a Lunar Module, although it is a few inches shorter than the real thing because the ceiling was too low!

* *The views expressed in this review are those of the author and not necessarily those of the speakers.*



NASA's Visitor Information Center at Canaveral. In the background are, left to right,: Juno I, Juno II, Delta, Gemini-Titan, Atlas-Agena, Mercury-Redstone and Mercury-Atlas. The Saturn IB first stage in the foreground is from vehicle SA-212, the second stage of which was converted into the Skylab space station.



The Gemini 10 spacecraft which carried astronauts John Young and Michael Collins aloft in July 1966, on display in the Swiss Transport Museum in Lucerne.

The LM is the largest example of the superb skill of the Museum's model makers. In the absence of the real thing, visitors to any museum have to make do with photographs and/or models and the Science Museum can be relied on to produce models of the highest quality. Of course, it takes time - a one-sixth model of the Surveyor lunar soft-lander took one man a year to build.

How does a museum set about acquiring material for displays? Much of it comes from organisations like NASA, ESA or other museums on loan or as gifts, while models may be bought off private makers or made in-house. The really interesting work, though, comes when an object surfaces for the first time - that's when museum researchers have to uncover the historical background by, say, document search and interviews. The Science Museums presently has 221 objects on display, ranging from satellite components to rockets. Most are on loan, including the Apollo 10 craft.

The 'Exploration' gallery is still being completed and the other space section up on the third floor will be completely rearranged. At present, it is rather randomly set out with exhibits such as the upper stages of a Black Arrow launcher, but in the next few years it will be mounted into two main presentations: Britain and Europe in space and 'What is a Satellite?' The centrepiece will be the integration model of our own X-4 Miranda Satellite (the flight model was launched by Scout in March 1974) with side displays explaining its operation.

Further ahead is a very important addition to the Museum's assets. Storage is presently limited to the basement and a site well removed from the building. They provide about 75,000 sq. ft. but an airfield with hangars adding 270,000 sq. ft. will be used in the future. The runway is still usable and will allow complete aircraft and rockets to be flown in; the hangar size will permit complete launchers to be shown.

The other three main exhibits in the UK are the Royal Scottish Museum at East Fortune (with Blue Streak F13), the Merseyside Museum (with Black Knight 11) and a largely audio-visual presentation at the planetarium in Armagh. But there are other locations with mainly a wartime flavour. R.A.F. Cosford has about 20 German missiles, the Imperial War Museum has a V-2 and the Royal Artillery Museum in the Rotunda has rockets dating back to the 1790's with a good selection of Congreve's works. Cranfield possesses a V-2 in excellent condition and the Royal Aircraft Establishment has a display of British rocketry dating back to the Second World War. Westcott exhibits early British engines which were developed into the Gamma motors for Black Knight and Black Arrow.

Museums are a vital legacy for the future. If we do not protect what we have now then it will be lost for ever. Unfortunately, in the US there does not seem to be a general policy for the preservation and disposition of artifacts. In such a rich hunting ground a lot appears to be going to waste.

A number of articles have been published in *Spaceflight* on space centres:

"Space at East Fortune" by Alan Lawrie, 1979, p.465.
"Space Exhibits in the U.S. Air Force Museum" by Andrew Wilson, 1979, p.18.
"International Space Hall of Fame," 1979, p.147.
"Space at the Cape Canaveral Air Force Station and some other space displays" by Andrew Wilson, 1980, p.167.
"Space Explorations at the Science Museum", by John Becklake, 1978, p.31.
"Astronautics on the Mall" by Dave Dooling, 1977, p.93.
"The National Air and Space Museum", by Dave Dooling, 1976 p.249.
"Armagh Astronomy Centre" by T. Murtagh, 1975, p.66.

ANDREW WILSON

CONFERENCE ROOM

The Programme Committee is endeavouring to improve the facilities at the Conference Room though this is not easy to achieve in a period of economic recession and when the Society already had problems in trying to maintain its publications at its accustomed level.

The Committee has identified a wide range of improvements which could be made to the facilities of the Conference Room and will attempt to implement them as and when opportunity presents itself.

As a first step the Speaker's Lectern, kindly donated by Pat Ladd some time ago, has now been equipped with a small shaded light - very useful when illustrations are being screened. Additionally, the windows have been fitted with blinds to provide a more adequate blackout.

Unfortunately, funds didn't run to the purchase of a new film projector; these are only available nowadays at astronomical prices, but a further second-hand projector was obtained (though not of the same type as the one we already have) so we now have the facility for almost continuous projection during film shows, without the awkward gaps which hitherto arose as each film was changed to make way for the next one in the programme.

The Council plans a major step forward in June when the Conference Room, hopefully, will get a new suspended ceiling, with lights fitted in flush. This will not only help the acoustics but will make the room more attractive by removing current eyesores.

SOCIETY T-SHIRTS

The old labels of *Small, Medium and Large* have now been superseded by chest-sizes, which are proving much more satisfactory.

The complete range is now as follows:-

White T-Shirts (with Society Logo)

32-34"   34-36"   38-40" 42-44"

Navy Blue T-Shirts (with Society Logo)

32-34"   34-36"   38-40" 42-44"

The new Navy-blue T—Shirts, particularly, are proving very popular.

The price of the shirt remains the same, i.e. £3.50 in the UK and £4.00 ($9.00) abroad, post free.

THE DISCOVERY, CARE AND FEEDING OF INTELLIGENT ALIENS

By Peter Molton

Introduction

FROM THE VANTAGE POINT of our present civilization, fixed more or less on the surface of the Earth with occasional forays to the Moon, we are in an incredibly poor position to speculate on the presence or absence of intelligent life around stars thousands of light years across the Galaxy. Yet we still do it, as this article and many others will testify [1]. Speculation is an age-old human trait and it does not appear likely that it will go away soon. Fortunately, we have logic as a tool to assist us in our speculations and keep them within some sort of reality boundary. If our speculations go awry, it is usually because we have made some illogical or unfounded assumptions. In this article, I attempt to apply a logical framework to speculation on the natures of our intelligent interstellar neighbours, if any, and to suggest ways to approach the solution to the question "are we alone?"

There has been a good deal of talk recently about the 'Fermi Paradox' [2]. If the Universe is as full of potentially life-bearing planets as current theory says, then where are the extraterrestrial explorers who presumably would have discovered Earth many times? Actually, there is no paradox, only several possible answers to the question. These are:

- Intelligent aliens do not exist or are very rare;
- They do not know that we exist, presumably because
  - (a) there are few of them and space is big, or
  - (b) they have no interstellar capability or interest in communication;
- They have no interest in making their presence known to us, although they do know about us;
- We are deliberately isolated, as a potential danger to them.
- They are already on the way, in a Galaxy-wide colonization.

If we are virtually the only intelligent life in the Galaxy, a possibility that is aesthetically distasteful to the author, then there is a vast opportunity for us to spread out and populate, if we want to. We would end up with Asimov's scenario, expounded in his science fiction books (e.g. the Foundation Series) where our same old trivial human problems come up again and again under different suns. How dull! However, the Fermi Paradox in this case reduces simply to the question of why the origin of intelligent life on Earth should be such a rare accident. (The alternate possibility that population pressure causes expansion and extermination of races – such as ourselves – competing for planetary space does not even hold true on the Earth, where population density has tended to stabilise as countries become technologically advanced).

Another possibility is that such life does exist, but that the period of curiosity about other races in space may be a very transient one in the lifetime of a species. The question of life elsewhere may simply seem totally irrelevant to such a race, intent on getting from its origin to its extinction with the minimum of pain and effort. The scientific revolution on Earth has been a very brief moment in our history, and there are many signs that it is already fading (reduction of funds for basic research, declining student enrollment in the sciences, etc.). Either a cataclysmic series of nuclear, chemical and/or biological wars may cause an anti-science movement back to the simple life, or the technological rate of progress may simply fade away through lack of continued interest.

Intelligence itself is not an *a priori* reason why a species should explore space. Curiosity – the need to know – is also critical and in our case we require some material benefit or reward for the pain and cost of exploration. Commercial motives drive us, or religious fervour occasionally but rarely just plain curiosity, but never intelligence itself, which is a potential rather than a driving force. Al least, the explorer may just be curious, but the sponsor wants a positive material benefit for the risk involved. So it was with Columbus, so it will be with our first interstellar explorer. Other races may have different motives but we can only guess at what they might be.

The reasons, then, why we may not have been discovered by intelligent extraterrestrials, comes down to:

- They are on the way but have not yet reached us;
- The origin of life is a rare or unique event;
- The origin of intelligence is rare or unique;
- The combination of intelligence, curiosity and greed may be rare or unique to us;
- Discovery of a workable interstellar drive may be a rare chance event;
- Exploration may be a juvenile stage in development of a species.

Space is so large that the element of chance must enter into our speculations. Also, life took a finite but unknown time to originate on Earth and it could be that we may have been one of the first races to evolve intelligence. In this case, we represent the tip of the wave, with the bulk of other races following behind us. This is an unlikely thing, but remote chances occur all the time!

Returning to what little data we have on our own origin, just how likely is it that any of the above reasons are true? In previous articles [3, 4] I argued that life's origin on Earth was inevitable given the set of conditions that

Is anybody there?

presumably prevailed. This view is not mine alone, but has been expounded by many authors since Darwin. Recent evidence on prebiotic evolution as simulated in the laboratory continues to build on the previous assumptions: organization of reproducing chemical entities from a random mixture of chemical compounds is not only possible, but follows logically from recent work on non-equilibrium thermodynamics of hypercycles [5]. The formation of the genetic code and its function in directing protein synthesis appears now to be a direct function of the structural chemistry of the nucleotides forming the DNA and RNA; separation of optical isomers and selection of one enantiomeric form over another also appears to follow a natural sequence of events; even our estimate of the number of years required for all of these events to happen and give rise to living cells is continually decreasing, because of the discovery of ordering processes which make sense out of processes previously thought to be random. The rate of evolution of a living organism is also much higher than was formerly thought possible. Of the 4-5 thousand million year lifetime of the Earth, it now seems likely that there was life as long ago as 3 thousand million years. Given that the origin of life on Earth now appears to be as much a directed, non-random process as a rock rolling downhill, and that by all accounts planets like the Earth may be rather common, should we not expect life to be also common? Of course, individuals may take issue with any of the points made above and argue for a much rarer origin of life. Taken together, though, the evidence for life being a normal event in an Earth-like planet's history is rather convincing, as the data continues to come in from laboratory experiments and paleogeochemical examination of ancient rocks.

Regarding the origin of intelligence and the other traits necessary for space exploration (curiosity and self-interest), there is still a considerable puzzle. Self-awareness still seems to be a uniquely human function, although some experiments with dolphins suggest that they may share this with us. At what stage does a clever animal become a creative, thinking, intelligent being? And why, of all animals, should humans have been selected? We have to postulate some sort of selection pressure unique to humans, because otherwise we would now have a multiplicity of intelligent species on Earth. It has been said that if Man had stayed in the trees, he would never have needed his oversized brain. What would happen if Man became extinct – would another species evolve with intelligence, or is intelligence a one-time experiment like the dinosaurs? To my knowledge, there have been no satisfactory answers to these questions, and so perhaps we are unique because we are the result of a lucky accident. However, the converse is equally likely to be true, given no evidence either way.

Work with dolphins has given us the concept that maybe there are other manifestations of intelligence than those that result in a machine civilization. If anything, dolphins are gentle, philosophical creatures, if they really are intelligent. The fact that we have so much trouble even deciding on their intelligence or lack of it indicates how much this concept is strange to us. How are we going to fare with aliens, if we cannot decide if a warm-blooded mammal and close terrestrial and biological relative is our intellectual match?

Dolphins, of course, would have trouble developing a machine civilization. They lack hands and live in water. This precludes their smelting metals, although native metals are available for working. It would also be rather difficult for them to learn anything about electricity in a conducting saltwater medium. There are many other factors which would force the dolphin into a thinking rather than a doing mode. There is an even closer analogy – the ancient Greeks abhorred manual labour (their own, that is – they used slaves!). Even successful human civilizations have shown a remarkable lack of curiosity and drive!

Given that life may be common, the probability that life will evolve, that intelligence will occur, that other factors will favour technological development, that the desire will be there for searching for extrastellar cousins (including us) – the probability for each of these is still going to be less than unity. We will end up with a version of the famous Drake equation for the probability of existence of interstellar neighbours. Some people put the probabilities at each stage so low that the net result is that we would be effectively alone in this Galaxy; others, including myself, put each factor at 0.9 or above, making many thousands of millions of extraterrestrial intelligences available for contact.

Assuming for the moment that there really are many intelligent species yearning for contact with other species, and that there is a real possibility for interstellar travel (we know of at least six potential methods ourselves for travel at sublight velocities), we return at last to the Fermi Paradox: where are they? The only way we will find out the true numerical values for the parameters in the Drake Equation, and hence the true number of space-faring civilizations in our Galaxy, is through exploration ourselves, unless in the meantime some friendly alien drops by with a number to give us.

The assumption that life is common in the Universe cannot be proven right now. Barring that elusive extraterrestrial contact, it will not be proven or disproven in the foreseeable future, unless NASA and other agencies suddenly discover an interest in theoretical physics and pursues a faster-than-light drive (still theoretically impossible). One way in which we might obtain some insight is through various radio transmitting and receiving projects (Ozma, etc.) as long as we do learn of apparently intelligence-directed signals. Since we *are* stuck close to Earth, we do the best we can and we either listen or send radio signals on presumed universal frequencies, hoping in this way to contact intelligence. However, this is an extremely long shot indeed and should not raise our hopes unduly. In looking for signals from other intelligences we make some unspoken assumptions for which we have no foundation in fact. One of these, of course, is that there is someone listening, but this may not even be the gravest. Consider, that if we do receive signals on one of our selected listening frequencies, it still may not prove the existence of intelligent neighbours – rather, it may as in the past be an example of a natural but previously undiscovered phenomenon, such as pulsars. How will we ever know, unless the message is truly unmistakeable? And how could such a message be unambiguous? Coming from an alien race, there would be an understanding gap. The underlying cultural assumptions of the terrestrial Eastern and Islamic cultures make any sort of understanding difficult, even though the words of the various languages can be translated. We would not fare very well with an alien culture that 'writes' in circles, spirals, or 3-dimensional helices and our messages to them (assuming a square notation) would be equally unintelligible. Even here we are assuming that a written language such as ours is a universal constant.

Another problem with attempts to communicate remotely by radio is the tremendous number of possible locations in space, frequencies and forms of message which can be sent. To pick up a radio message that has travelled light years requires a fairly concentrated search of a narrow area around a selected star. Frequencies chosen are chosen because they are multiples or submultiples of 'natural' frequencies such as the 21 cm^{-1} band for neutral hydrogen, or hydroxyl, or similar universal frequency. It could equally well be argued that a communication frequency should be as far as possible away from such sources of natural noise! There is such a multiplicity of possible message forms, also, that sooner or later we will find an

apparently directed 'message' through chance alone. One recent suggestion is that a virus could be coded in such a way as to constitute a message (which it probably could) [6]. Heaven help us if we examine the entire natural world for messages left by passing aliens. Stonehenge would be a likely place to start. We would of course find many messages and still never know if they were real or not. Shades of Von Daniken and Epsilon eridani!

The final problem with radio messages and listening for messages is, of course, the assumption that radio frequencies are the preferred way of interstellar communication. Intelligent races may well set their definition of the minimum technological level worth talking to higher than ours and be sending furiously in some medium as yet unknown to us.

Whatever medium we choose for our remote communications we make yet another assumption based on our terrestrial experience – that intelligent aliens are concentrated on planets circling stars. This assumption has recently been challenged by de San [7] and is a reasonable extrapolation from the recent interest in space colonies for power or manufacturing purposes. There is even a human example in the form of the automobile. Given that space colonies can be built, they would be more comfortable than the surface of a planet (rain could be programmed to fall at night, for instance, and seasonal temperature variations could be eliminated). What more natural to mankind than to put a motor on one's home and go touring? A number of science fiction stories deal with this topic – for example, Clarke's *Rendezvous With Rama*. For whatever reasons, it is at least a possibility that our Galaxy is full of nomads who spend most of their time travelling and only stop off at a planet to relieve the monotony. In this case, we would be directing our radio signals and ears at just the places least likely to have anyone there.

Continuing with the basic assumption that there are many intelligent space-faring races in the Galaxy (we have to make an assumption somewhere!) why have they not discovered/contacted/come to visit us? Let us also assume that our presence is known to them, since a discussion of relative rarity of contact between races cannot lead to any useful conclusions. There are three possible reasons for the lack of a firm contact, such as a spacecraft landing in the Piccadilly Circus in the rush hour. One is that such a contact would damage *us*, another is that it would damage *them*, and the third is that they have no interest.

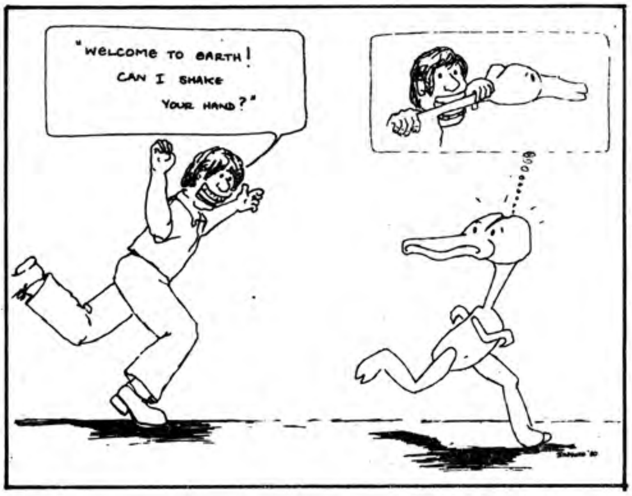
The theory that contact with intelligent extraterrestrials who are prepared to flaunt their superiority with a sort of galactic technological welfare system may stunt human development has been expounded elsewhere [8]. Perhaps we could withstand it and take advantage of it, perhaps not. In any case it has not happened, since such a contact would by definition be unmistakeable since it would impact directly on our societies. The idea that intelligent aliens clustered around the Earth and studying us may be *afraid* of us has not received much attention. It is a rather startling idea, but recent human events may give a clue. Human industrial civilization is less than 200 years old; in that time we saw the rise to power of Britain and the U.S., among others. Technology had given these countries the edge over others, an edge which led to the formation of large empires ('field of influence' is a euphemism). Except for fear of starting a world war, several nations have the physical power nowadays to impose their wills on weaker nations

The situation may be analogous to a technologically advanced alien civilization *versus* humanity. The fact is, not only do these powerful nations not use their power for domination

they are becoming more and more *unable to defend themselves*. The USA is the most obvious case in point, although I believe that most European nations and Japan would act similarly. In the case of the USA, popular opinion caused the ending of a war in Vietnam, and more recently saw a situation in which 50 of that country's nationals were forcibly incarcerated as 'hostages,' and all that was done (to date anyway) was to apply diplomatic pressure. True, there are sound economic reasons for not attacking an oil-producing nation, but such reasons have never before caused restraint where such a matter of principle is at stake. It is as though an increased level of awareness that the other side are people too, however misguided, is becoming prevalent. The posture taken by the U.S. is that of a sorrowful parent to a misguided child, rather than that of a powerful nation against an enemy. If this increase in tolerance with level of civilization is a natural evolutionary function in the coming of age of a race, presumably a very advanced (space-faring) race would have even more of a problem in defending themselves against human attacks (i.e., by misguided primitives who don't know any better). Such attacks are in fact very likely, since humanity has always taken what it wanted from other humanity until very recently and in isolated cases. Is there any reason to suppose that human/alien relations would be any different? And why take the risk? It is easier not to make contact and observe from afar than to risk personal physical damage in a race to which life may be very precious. Anyway, this is one theory for lack of contact and it may be worth some discussion.

The third possibility is the opposite of Charles Fort's "I think we're property." If life is common in the Universe, and G0 dwarf stars such as the Sun certainly *are* common, then similar physical conditions may have evolved human-type creatures as a drug on the market. (Alien: "Oh, here's another of those boring oxygen-breathing mammal places; let's go on to an interesting carbon/chlorine biochemistry place I know that's just around the corner"). We may not have been contacted because we are not considered worth the effort. Certainly our claim to be *civilized* must sound rather thin. Our technology creaks along on oxidizing fossil fuels, our societies lurch from crisis to crisis with much flag-waving and spear-shaking, and two-thirds of our population is starving, illiterate and crippled with disease. To an outsider it would be rather hard to make any distinction between the flower of humanity revelling in relative comfort and the richer of several tribes of Neanderthals. If we are contacted, it is likely to be by alien anthropologists and collectors of primitive art rather than by diplomats offering us partnership in a Galactic Union. In fact, scattered colonies of humans may exist in zoos throughout the Galaxy (Marie Celeste and similar examples abound). We *could*, if we only stop bickering, put this world to rights within 20 years. Civilized? Hardly.

One other factor that is curiously human may enter into the discussion here. The ubiquitous UFO is supposed to be nothing more than an alien spaceship and many books have been written describing rather detailed and lengthy contacts. Just suppose that only *one* of these stories is true. Would we believe it? *Do* we believe it? No! Because the supposed spaceship landed in a remote area, no matter how many reliable witnesses there were, and because humanity is full of liars. The simplest hypothesis is that the observers were hallucinating, drunk, simply lying for effect, or mistaking Venus or a weather balloon for a spacecraft. We have to face the fact that one of these stories could be true. We could have been contacted many times, but we simply do not believe it. Of course, if a UFO landed in the middle of a highly populated area in a fanfare of publicity, and proceeded to disgorge aliens saying in slightly accented English, "Take us to your leader," we might believe it then. However, this would place the aliens in a delicate position where a mob might attack them (certainly the Army would feel obliged to show off a few tanks), even assuming that the concept of a 'leader' means anything to them. Why would they do any such crazy thing, just because we are not



willing to believe individuals who saw them land in the woods? That's *our* problem! Humanity may be the only race in the Galaxy to use the lie as an accepted business tool.

Hence, discovery of intelligent extraterrestrials is a chancy thing, particularly if we wait for a visit that may never come, for whatever reason. Even making a positive effort and sending radio signals to the nearer stars is a real shot in the dark. It is not even particularly wise, because we might get a visit from the rent collector or even the local headhunter. No, the only way we are ever likely to settle this question about the existence of intelligence elsewhere is to *become* that intelligence to someone else – by going out there and exploring, either in person or through robots. That is why *Project Daedalus* is so important in the long run – it shows that we can do it if we try.

Care

Suppose that one day, either through our own efforts or through others we do make contact, what then? What will they be like? Many assumptions have been made, from H. G. Wells' *War of the Worlds,* where Earth is almost taken over, to cases where aliens in effect say "Oh, you poor people! Here, let us help you." One of my favourite stories is Murray Leinster's *The Greks Bring Gifts,* where an alien visitation and open-handed policy is revealed as intelligent self-interest on the part of the aliens, leading to exploitation and slavery. We should be very careful, which is why I believe that remote probes are preferable to radio signals – the probes have a chance of remaining unobserved while they collect data.

Just as one example of how human thinking can affect our assumptions, take the simple case where a friendly human is walking along, sees a UFO land and an alien get out. What is the human to do? (We assume that the alien knows nothing of humanity and its quaint customs). The obvious friendly thing is to walk forward towards the alien, either holding the hands out to show that they are empty, or proffering one for a handshake, together with a broad smile of welcome. The alien on his part could see a primitive, quite possibly oversized, repulsive man bearing down on him with the universal gesture of imminent attack (grasping members over the head and held forward), moving with disturbing speed. Alternatively, he could interpret the smile, or showing of teeth as an invitation to come and be eaten, with the offering of the hand (physical contact) warning of an attempt at capture. It all depends on the society one lives in. The alien would of course promptly take off in a blue funk and tell all his friends to "stay away from there!" Perhaps this is why we suffer from galactic ostracism. Or, if the alien came from a fairly aggressive race, it could go hard on the human. If an alien attack on a man happened to be witnessed by other humans and well-documented, the result would be a boiling out of primitive war-canoes from the Earth in search of alien blood.

This scenario is one that could quite possibly happen even if the alien is biochemically and psychologically quite similar to a human. All that we assume is a different background of society in which common human gestures have different meanings. We have by no means explored the limits to life and have no basis to assume that our visitors would be remotely similar to us in their evolution, racial history, outlook, morals, motives or intentions. Some further examples of alien/human contact scenarios were given in a previous article [9]. Without repeating them here, the message is that the little 'world-pictures' we carry around in our heads to provide us with analogue answers to new experiences may seriously mislead us when dealing with aliens. It is very difficult to remove all prior prejudice, assumption and misinterpretation even when dealing with another human (how often have we said "I don't know why, but I disliked him as soon as we met?") Dealing with aliens may be even more difficult, unless they have first taken the trouble to study us very thoroughly and unless we have someone prepared to act – and trained to act – without prejudice. Currently we have no-one who can really do this.

Apart from purely social differences, we will have to watch out for some other potential problem. What will be done if the visiting emissary has an offensive body odour (such as rotten eggs), or reminds us strongly of a pussy-cat? We will tend to apply our perceived character for smelly individuals or felines to the alien, regardless of conflicting signals which he/she/it may be sending. Beauty may be only skin deep but it causes us to put the person in question into a 'box' full of mental attitudes based on and generated from our prior experience with similar individuals *in appearance.* Such examples as 'blondes are dumb,' 'redheads have bad tempers,' 'sloths are lazy' – totally wrong, but unconsciously still there and causing us no end of trouble because we act instinctively as though they are true. When the signals sent by an individual, unconsciously in the form of body language, do not match our preconceptions, we tend to get confused, angry and distrustful, and to act as though the individual were trying to trick us! This may seem to be mere harping on a triviality, but any skilled negotiator knows how difficult it is to push such prejudices aside. In human/human interactions, there are many 'givens' (common language, outlook, belief, etc.), but in human/alien interaction there are no givens. We have to start with a completely empty book and build from there.

If we cannot simply shake hands and sit down to learn one anothers' language, what can we do? One idea is to exchange artifacts from which one can learn much about the nature of one anothers' civilizations. Unfortunately, we would have no idea if an alien TV set was a bomb – or a TV set. Anyway, if their culture is sufficiently advanced technologically to have interstellar space flight, they would presumably be as far beyond the transistor as we are beyond the radio valve (tube). Isaac Newton could have undoubtedly worked out the principle of a radio valve, since it is a physical device of a type similar to machines of his own age, but a transistor, a simple block of metal, would have eluded even his acute intelligence in trying to figure out how it worked. In this sense, those who would communicate through radio have it much easier, because once a common working basis for the symbology had been worked out there would be no problem with interpersonal reactions. Of course, we would not learn much about the aliens either, only what they wanted us to know.

The problems with alien contact with us, instigated by

the aliens, are quite severe unless we are led by the hand. This requires in turn that (a) such contacts must be almost routine, and (b) the aliens have sufficient interest in us to learn our reactions and to study our technology. This requires a lot of investment on their part. If a first contact takes place on Earth and goes smoothly, with mutual understanding, we will know that we have been studied in detail, for whatever reason. If a first contact goes haltingly, with mutual misunderstandings, we *could* assume that the contactor is either new to the game, or a casual passerby, or both. In any case, rather than exchange of greetings (handshakes) or gifts (TV sets) an experienced alien negotiator will probably start off with the equivalent of a stick drawing pictures in the sand. The less overt technology there is around to be misunderstood, the less likely we are to assume that a translator or computer is a weapon, on both sides.

Whatever the actual scenario, the first definite contact between human and intelligent alien will be fraught with significance for us. It will change the course of human history, but whether for better or worse we will not know for some time afterwards.

Feeding

The title of the article was partly facetious, but in the context intended here, 'feeding' means interaction between human and alien. Assuming that a successful first contact has been achieved (i.e., nobody died) what will be the natural results we can expect? To a great extent this will depend on the character of the alien intelligence and also on the expectations of the human participants – a rather obvious statement. However, in our speculative literature, we have a disturbing tendency to extrapolate what we see as the course of human social evolution, and to say "aliens are more advanced, so they must be like us as we will be then." If we are just climbing out of the social morass of mutual lies and exploitation, aliens must be more honest and more ethical because they are more advanced. This assumption just *does not follow logically* and it could be very dangerous for us. Humans are omnivorous, gregarious, tribal mammals that bear living young and form lasting attachments to them. This in turn gives us a set of strengths and weaknesses which can be exploited, One way to get a man to do almost anything is to threaten his family. Other species on this planet have very different behaviour patterns, which in turn are derived from their own evolution. They just happen not to have our intelligence – but if they did, how different would their behaviour be?

There is perhaps one assumption which is strictly human that we would be safe in also attributing to all alien intelligence with which we come into contact. Briefly put, it is the universal "what's in it for me?" No one does anything without expectations of reward, whether the reward be material, increased personal security, or the glow of having done an act without expectation of reward (feeling good is a reward, surely?). We may expect the alien to contact us because they expect to get something out of the contact. To make such a contact believing it to be literally *useless* is illogical for any species.

If we sit on the Earth and wait for contact we are giving away our one and only present advantage, because the aliens will know where we are and that we are helpless and localized on one planet. Our home could be rendered uninhabitable and we could go with it. The contactor has all the cards in this game. If we go out ourselves and make contacts we will be secure in the knowledge that if we fail, at least our fellow humans will not suffer.

It may well be that with increased levels of civilization comes an increased tolerance and a desire to do good deeds, perhaps associated with an aversion to actually getting our hands dirty ourselves – this could be a universal trait, but it would be unwise to commit our whole planet on this assumption. What if we are wrong?

After our first contact, then, we would need to find out as much as we can about the other intelligence, preferably in such a way that we could have confidence in our data. The best method would be an unobstrusive examination of their home planet if we are technically advanced enough at that time. Otherwise, we have to check their behaviour and analyze it for slips and inconsistencies. The overriding requirement will be to find out the answer to the question: "What do they really want?" The mutual relationship would expand greatly if both sides could be truthful and could each gain from the other without losing something precious. In this, the contact development will follow good negotiating practice in business on Earth. Gradually, we would learn to deal more directly with one another, starting with something really small and leading up to bigger things. But we have to have something to sell! If we are in the position of receiving hand-outs of new technology and unable to give anything in return, we suffer a serious loss of pride, even though the aliens may feel good. The general failure of financial assistance to poorer foreign governments to generate much goodwill on Earth is the same sort of thing. Right now, we really do not have very much to offer – which could be one reason why we feel neglected.

Contact in itself, then, need not necessarily be good. The timing is crucial. If we sit and wait for contact, we will always be in the position of poor cousins needing welfare and feeling sorry for ourselves. On the other hand, if we assume that someday we will meet intelligent counterparts in space and prepare ourselves and our planet so that we need not be ashamed, we will be in a much stronger position. To do this, we need to achieve some pretty spectacular things. We need to stop bickering among ourselves and killing each other and redistribute the food, education and technology so that we have a global society; we need to develop space flight so that we are limited at least to the Solar System and not to just one planet; we need to press ahead with theoretical research on a priority basis, so that we can develop the means to go into interstellar space ourselves; and we need to adjust our thinking so that we do not use human prejudice to judge alien actions. This is a tall order, so let us get on with it.

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The 'Salyut 6 Mission Report: Part 7' and 'Satellite Digest-147' will be published in a future issue.

VISIONS OF SPACE FLIGHT

By E.J. Coffey

Introduction

"Do we still think primitively?" was the question asked recently by Walter Elliott [1]. The very transition the ancient Greeks made from animistic, anthropocentric thinking to theoretical thinking clearly shows the possibility of changing one's style of thinking. Science itself has greatly benefitted from the distinction made between 'subjective' and 'objective', of a 'real' world underlying our perceptions, but it has done so at the cost of almost completely excluding the sentient, percipient, and thinking observer from its deliberations. The study of the psychology of creativity [2] and the logic (or utility) of creativity [3] have thus taken second place to the investigation of the macrophysical world.

Thought and Consciousness

Perhaps, says Walter Elliott, "we now need another new and radical way of thinking ..." in order to accommodate both thinking and consciousness into a "truer perspective in the Universe as a whole." The anthropic cosmological principle goes far towards redressing the balance by overcoming the traditional dichotomy between "observer" and "observed", revealing the former as an indispensable part of the latter. Indeed, many scientists have speculated that the Universe is only comprehensible because we are, in some sense, part of it, our brains being constructed in accordance with natural physical laws. To the question, "Do we still think primitively?", there are at least two answers. First, yes we do, yet unavoidably so, for our capacities for adaptability and creativity are an inheritance we share with our extinct apelike ancestor and the livng apes, but which we have developed to new heights of sophistication [4]. Second, we all have the potential to profoundly improve our present largely untutored and primitive styles of thinking, the possibilities of which are shown through a deeper understanding of the accomplishments of visionary thinkers, and both the psychology and logic of creativity.

Visionary Thinkers

We look back in admiration at those certain individuals who produced those towering conceptual schemes which have shaped the modern world, and still propel it forward. Often these were achieved in spite of many difficulties, at great cost to themselves, and even the censure of their contemporaries. The compulsions driving them have been described eloquently by Arthur Clarke [5]. Visionary thinkers, whether artist or scientist, are compelled to do what they do less for finding beauty or increasing knowledge, than for the "simpler, more fundamental, reason that they had no choice in the matter - that what they did, they did simply because they had to do it." What is more, every human accomplishment begins as an idea, a dream, or a vision, in the consciousness of individual human beings.

The rocket pioneer Robert Goddard [6], to whom we owe an incalculable debt, provides a potent exemplar of these issues. His imagination had been stimulated by the speculative ideas of Pickering about a lunar atmosphere, volcanism, and life on the Moon, H.G. Wells' science fiction, and Lowell's claims for intelligent creatures on Mars, amongst others. Almost singlehandedly Goddard had gone on to make calculations on rocketry and space flight, to work on fuels, as well as to actually design and test rockets. A lone but devoted researcher, he endured a derisive press following a press release after one of his experimental successes. He did not stop here but went on to envision investigations of the composition and circulation of the upper atmosphere, gamma-ray and UV observations from above the atmosphere, a Mars reconnaissance vehicle, non-relativistic interstellar flight, solar-powered and nuclear-powered craft, a method of suspended animation, the possibility of extraterrestrial creatures analogous to man, and the necessity of manned interstellar flight to other stars, in the far distant future, when the dying Sun made the Solar System unihabitable. Intriguingly, such ponderings began in the boughs of a cherry tree where, in 1899, at the age of 17, he experienced, in the words of Carl Sagan [7], "a kind of epiphanal vision of a vehicle that would transport human beings to the planet Mars." So vivid was this image that it caused him to devote himself to this very task and, each year, to return to that same tree to recollect the memory. Parallels can be drawn between this and the experience of the 16 year old Einstein when he visualised what it would be like to travel on a light-beam, though it was to take another ten years to resolve the conflict with the prevailing assumptions.

An important distinction can be drawn between visionary thinkers like Goddard and their predecessors. The notion of travelling to other planets was not new to Goddard's time but was to be found in the romantic speculations of writers like Lucian of Samosata (2nd century), or Johannes Kepler, and Cyrano de Bergerac (both 17th century) which seem, at first sight, eerie anticipations of what was to come. Two factors may help to explain this: speculation is the inevitable by-product of man's ability to imagine; the implicit recognition that machines extend man's physical range, and compensate for his bodily limitations, make it relatively easy to imagine that some kind of machine or vehicle could carry man through the air, beyond the Earth to other worlds, to breathe and travel under water, emulate man's capabilities, and so on. In contrast, the rocket pioneers did not resort to idle speculations but to reasoned extrapolations from well-established observational, experimental and theoretical knowledge.

Perceivable Models

Carl Sagan has speculated whether the nighttime dreams of flying, or Goddard's vision, are nostalgic reminiscences of our lost arboreal heritage. Jack Williamson [8] has also wondered whether space pioneers like Goddard, Tsiolkovsky, Oberth, or O'Neill, are individual cells of a superorganism, "created to guide us back toward our birthplace among the stars." At best, such metaphysical notions are merely metaphors for man's compulsion to ponder and explore the mysteries of creation, and accomplish his dreams. In fact, the occurrence of visions is not the exception but the rule! All humans experience them, though these are of variable intensity, content, and sensory modality. Curiously, although the importance of images has been well recognised by artists and the best scientists (like Faraday, or Einstein) the generally prevailing scientific view either denies or ignores them, or is unable to fit them into any

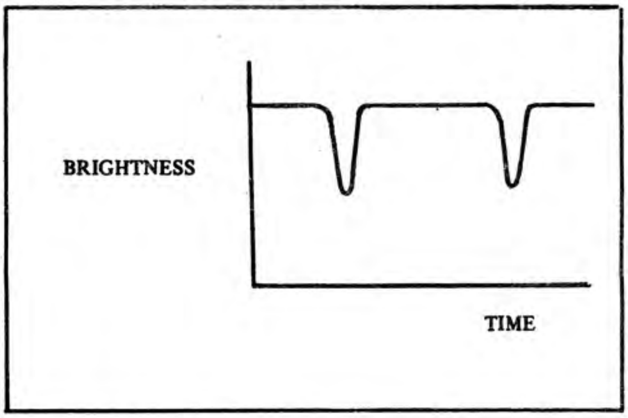

Fig. 1. Algol:observations.

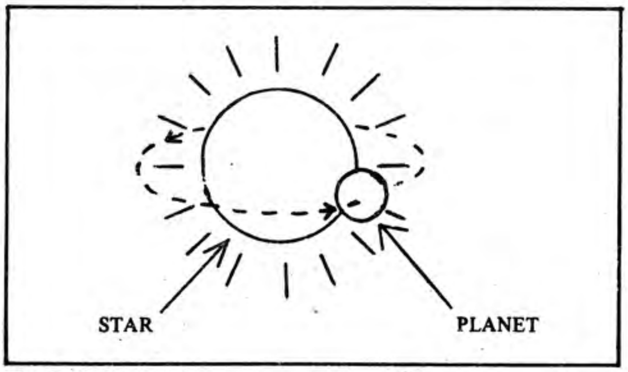

Fig. 2. Algol:model.

really viable theoretical framework.

From his consideration of the logic of creativity the philosopher of science Karl Popper has shown that our theories are purely hypothetical or conjectural constructs. As a consequence, no theory can ever be proven to be true, only refuted or, at best, corroborated: our knowledge is thus only tentative and corrigible. Such a view has profound consequences; hypotheses, to be scientific, should be clearly stated, be subject to critical appraisal, and make testable predictions. As to how creativity occurs Popper suggests that theories cannot be logically deduced from sensory experience, and are thus only a matter for psychology.

Arthur Koestler's examination of the psychology of creativity is relevant here. The creative act incorporates three simultaneous phases: the shift of attention to previously ignored or unnoticed phenomena; the spontaneous welling-up into consciousness of an image (in the form of an analogy) as the result of the former; and the overcoming of a conceptual block (a preconception blocking creativity). A deeper understanding of creativity is implicated in Rudolf Arnheim's thesis [9] that perceiving and thinking are different aspects of the same phenomenon. With the recognition by psychologists that perceptions are perceptual hypotheses, it can thus be concluded that perceptual and intellectual hypothese, hence images, or visions, are not fundamentally different. This is supported by Thomas Hoover [10], when commenting upon the growing realization by various psychologists and computer scientists of the staggering complexity of cognitive processeses, "academic researchers have found that human intelligence is intimately tied with human perception. It is going to be very hard to duplicate one without also duplicating the other."

The widespread notion that perceptual and intellectual hypotheses are different partially derives from the fact that science is not restricted to directly perceived situations, to appearances, but seeks to explain them in terms of inferred underlying mechanisms. An illustration of this [1] is the deaf-mute John Goodricke's interpretation of the regularly repeated dimmings of Algol as due to a planet eclipsing the star [11], although the modern interpretation is more refined. Generally, this is as far as descriptions of scientific discoveries go yet, as such, are very misleading, tending to perpetuate mistaken notions of the actual psychology of creativity. In this case they can be inferred: once Goodricke had confirmed that the dimming was a regularly repeating occurrence it took him two days, presumably attempting different interpretations, to light upon an adequate analogy; it is quite possible he even experienced a vision, analogous to other creative individuals, though not necessarily especially vivid, of a body revolving about and eclipsing another. The interested reader, by applying the model [Fig. 2] supplied to the observations, may see that rather than an emancipation from perception, science involves the employment of previously acquired analogies or perceivable models. Clearly, no real distinction separates what is perceived directly or what is imagined.

Mental Spaceships

Nigel Calder has employed the term 'mental spaceship' [12] as a synonym for "imagination". Our imaginary gedanken-experiments are like spacecraft probing the unknown. They may carry us to distant places to reveal new phenomena and new details never previously anticipated. Like spacecraft they may also go astray or crash land. This is because there exist no absolutely reliable connections between experience and our hypotheses since these latter derive from similar mechanisms as delusion, fantasy, illusion, or hallucination. What is more, our hypotheses are human inventions, which is why Albert Einstein described thinking as the "free play with concepts". In this, intuition, though fallible, may be our only guide, and the means by which we connect our sense impressions into conceptual schemes. Can we also launch "mental spaceships" comparable to visionary thinkers like Goddard, Einstein, and others?

While this is not impossible much higher demands are placed upon the individual, such as due to the extent of the information explosion, and will require a great elaboration of those qualities generally associated with genius: childlike simplicty, passionate curiosity, artistic sensitivity, powerful intuition, flexible imagination, intense and persistent concentration, and autonomous thinking. This will be especially true of those dealing with esoteric phenomena, as in relatively and quantum mechanics, in which familiar analogies and common-sense notions have limited applicability. The difficulties of visualisation here signify more the limitations of everyday human experience than the failure of perceptual hypotheses. It does not reduce the recourse to pictorial aids for thinking such as drawings, graphs, or Feynmann diagrams. The latter [Fig. 3], for instance, represents the modern equivalent of a 'collision' between particles, and shows this, taking into account Heisenberg's uncertainty principle, as occurring via the exchange of real or virtual particles.

The Scientific Renaissance

With the recognition, from their crucial role in creativity, that images or visions represent the very essence of thinking, the individual can actively strive to improve his style of thinking, and compensate for its deficiences. Possible future developments are suggestive in this regard. Ronald Siegel [13], whose study of hallucinatory experiences literally make him a cartographer of consciousness, indicates a fascinating possibility. "Much of the information stored in the brain is in the form of images. By studying hallucinations we are learning about the storage-and-retrieval process of these images. We will eventually be able to control the retrieval of information almost at will - including thought imagery, daydream imagery, sleep imagery, or hallucination imagery." Space Flight has played an inestimable part in the scientific renaissance we are now undergoing. Future generations may even describe the present as the Age of the Spaceship, both literally and metaphorically (in the senes that Nigel Calder uses it), when, perhaps for the first time in the history of the Cosmos, a creature left his home world to explore the infinite reaches of the Universe, at the behest of a compelling and overpowering vision.

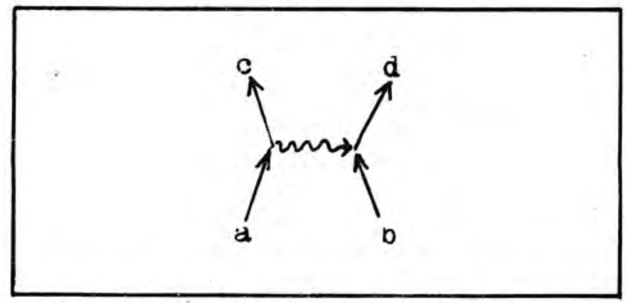

Fig. 3. The Feynmann diagram is a pictorial aid to thinking.

Concluded on p. 184

35th ANNUAL GENERAL MEETING

A Report of the Discussions

In the Chair:	Mr. G. V. E. Thompson	President
In attendance:	Members of the Council	
	Mr. A. T. Lawton	Vice President
	Prof. G. V. Groves	Past President
	Mr. K. W. Gatland	Past President
	Mr. P. J. Conchie	Chairman, Technical Committee

President's Address
The President welcomed all members present and said that, as indicated by the Agenda, the purpose of the meeting was to discuss Society affairs during the year from 1st January to 31st December 1979, though every opportunity would be taken to provide further information during the general discussions.

Although we continued to publish our magazines during 1979, we were also greatly preoccupied with the completion of our new HQ. On 1st May we were able to move in with the result that the second part of the year saw an immediate increase in our meetings activity, with yet further increases since then.

Although we found ourselves with greater resources, we were unable, for financial reasons, to do all the refurbishing and provide all the staffing necessary. Our main problem was still to meet the outstanding liabilities arising from the completion of the work to an operational stage. When this had been done, we would be ready to move into a new phase which, undoubtedly, would include:

a. Completing the capital work and acquiring further equipment
b. Enlarging our staff capabilty.

Mr. W. Edmead (Fellow) moved that the Report be adopted. This was seconded by Mr. P. J. Clark (Fellow) and carried unanimously.

Balance Sheet and Accounts
The Executive Secretary reported on the Balance Sheet and Accounts for the year to 31.12.1979. He drew particular attention to the problems that had faced the Council in this difficult period and pointed out one major change which appeared in the Society's assets, viz the Headquarters Building is now our major asset and is virtually complete. Future work will be related to internal finishing and fitting. Our assets would then be even further improved - a situation which would have seemed not even remotely possible only five years ago. The two major items under the heading 'Liabilities' were a £30,000 Bank Overdraft and a 5 year loan provided by the London Borough of Lambeth. Both had been discussed and approved at the 33rd Annual General Meeting. The Executive Secretary then went on to point out that our Society, essentially an academic body, - in setting about the enormous task of completely restoring and redeveloping a building - had undoubtedly tackled the largest single project ever undertaken in its near-50 year history. To do this in such a difficult economic climate and to achieve this work within budgetary limits set 2 years previously might, to some, have seemed almost miraculous. It was not. It was the result of very hard work, close attention to cash flow, and strict adherence to sound economies, both by the BIS Council and by the entire staff. Income and expenditure has just about balanced in spite of there being various initial unknowns, principally local rates, lighting and heating, etc. Other heavy costs were involved in publicatons and printing, where labour costs have undergone considerable increase. However the Balance Sheet showed a small excess of income over expenditure though, in fact, the Society had really completed a "quantum jump" from 2 rooms to the present headquarters in a highly satisfactory and competent manner.

Mr. F. R. Smith queried the value of the property and asked if it included any inflationary trends. The Executive Secretary replied that it did not. It was valued in the manner required by law and on the basis 'historic cost', i.e. what we had actually spent on it. An indication of real current values could be gained from the sale of the irregularly-shaped piece of vacant land adjoining the headquarters. Although only half the area, it had been valued at over £100,000, whereas the BIS had twice the land area on which stood a complete and newly-developed property. Future records might include a note which indicated the potential market value of the property but, the Executive Secretary warned, whereas bonds and shares have a real saleable value, property valuation is not that simple. Similar remarks could also apply, e.g. to queries on the values of fixtures and fittings.

Another questioner asked if a reasonable income was obtained from saleable items e.g. ties, etc. The Secretary replied that a small but significant income was realised from such items.

A query was raised as regards the Society entering into a 'sale and leaseback' transaction. The Executive Secretary replied that the Council *had* considered such transactions, but it would only be of value where the monies received were fully applied on a profitable income-earning basis. Although such an arrangement could provide an immediate cash benefit to the Society we would then - not being a trading concern - immediately revert to the position where, because of continuing inflation, the cash started losing value immediately. Our Society was better served by possessing its own headquarters, an asset which would show overall appreciation.

On the proposal of Miss E. Wright (Fellow), seconded by Mr. C. Ledsome (Fellow), the Balance Sheets and Accounts for the year ended 31st December 1979 were approved unanimously.

Benevolent Fund
The Executive Secretary drew attention to the Benevolent Fund and pointed out that if these monies could be incorporated in the Society's main accounts - without touching the Fund itself - the effect would be to present the Society in a strengthened financial position. However, to deal with it in this way required both the consent of the Trustees and of the Charity Commissioners as well as of the Society's Council. Legally, of course, it was not the Society's money. There was not even a requirement to publish the accounts or submit them for approval.

The position regarding Benevolent Funds had changed markedly in recent years. In many cases the original purposes had been overshadowed by State schemes. Whether the Charity Commissioners, for example, would agree to the complete re-negotiation of the Benevolent Fund arrangements was a moot point. Current indications were that it would be most unlikely: the best that might be achieved would be to incorporate such figures in the Society's Accounts, with the proviso that the fund was operated on exactly the same terms as before. This was not, however, a matter which lay in the hands of the Council or even the members of the Society.

Some members felt that the monies should be ear-marked for other specific purposes. Eventually, it was agreed that, should any arrangements prove feasable whereby the monies could be used more beneficially for main Society activities, the Council would advise members fully of such arrangements.

Appointment of Auditors
After clarification of the legal requirements for the appointment of Auditors made by the Executive Secretary, the President reported that last year's auditors (Messrs. Fraser Threlford and Co.) had offered themselves for re-election. On the proposal of Mr. W. Edmead (Fellow) seconded by Mr. C. Ledsome (Fellow) the election of Messrs. Fraser Threlford at a remuneration to be agreed upon by the Council was approved unanimously.

Council Elections
The President then announced that, in accordance with the Society's Articles, 4 members of the Council were due to retire. Election to fill the resultant vacancies would be made by ballot in the usual manner. In order to allow overseas members time to respond, 31st January 1981, as in previous years, was once again suggested as the final date for the return of the ballot papers.

This was then formally proposed by Mr. R. Ward (Fellow) and seconded by Mr. D. A. Liddle (Fellow) and carried, apart from one dissenting vote from Mr. I. MacKinley (Associate Fellow) who wanted to know "why the procedures mentioned in the Society's Bye Law 24 had not been met". Replying, the Executive Secretary pointed out that the procedures just adopted had been fully discussed and agreed at previous AGMs. A major consideration lay in the distribution of voting papers. It had already been recognised that the simplest and most economical way of doing this was by sending ballot papers out with *Spaceflight*. This practice had been adopted for many years now. The system had proved itself to be extremely satisfactory, in spite of minor delays in the turn-around time of *Spaceflight*. The matter lay in the hands of the AGM but if the Bye Law had been varied the Chairman would not have put the point to the meeting. The very fact he was doing so clearly illustrated that Bye Law 24 was being complied with.

The President concluded the discussion on Council Elections by pointing out that the vote just taken showed clearly that the procedure was very reasonable and enjoyed the support of everyone else at the meeting: Mr. MacKinley was a minority of 1.

General Discussion

A member asked if the "resignation of 4 members at the AGM" meant that, until the election ballot date of 31st January 1981, the Council would be four members short. The Executive Secretary explained that, at the AGM, the Council members concerned *offered* their resignations. The offer was not *accepted* until the election actually took place on the final ballot day. There was no question of resigned Council Members being 'in limbo' between the AGM and ballot day! Until decided otherwise by the outcome of the ballot, each Council Member up for re-election retained his position until the new results were declared. This was a practice which applied generally to hundreds, if not thousands, of other groups.

There was however, one exception, which could arise where for example, there were 4 vacancies and only 4 candidates offered themselves. In that case it was possible for the matter to be decided there and then at the AGM. This situation arose because there would then be no contest. Even so, there was then a choice of method, because the members present at the AGM could vote for candidates individually or collectively. In the former case it might be that one or more did not secure a majority of votes on a show of hands.

Mr. F. R. Smith (Fellow) thought this unfair for it allowed completely "new" candidates to enter office immediately whereas, if the number of candidates exceeded the vacancies, then they had to wait 4 months. The Executive Secretary replied that this was a material consequence of holding a ballot: it would be even more grossly unfair to seek to deprive overseas members of their votes. The President supported this as being a thoroughly British logicality. The Executive Secretary then added that this "seeming inequality" was thoroughly convincing evidence for using the "31 Jan" procedure **every time**.

Mr. I. MacKinley (Associate Fellow) said "I have been misrepresented here in the minutes saying this, saying that, and saying the other, 3 pages of it. Most of it I cannot accept. I support the idea of 3-4-5 months, for a ballot paper to get round the world. I support a democratic society: the point is, let's have the ballot papers and the nominations 3 months before the AGM far enough back in time to have the ballots at the AGM."

The Executive Secretary replied that it was essential to allow adequate time to vote: this was a major criterion of the system adopted. Mr. MacKinley interupted to say this was not why he was objecting. The Executive Secretary continued saying that the great majority of members overseas - and, indeed, all of the members at this particular AGM had (with the exception of Mr. MacKinley himself) already voted for 31st Jan. "At the previous AGM you were given a detailed account of why this date was chosen. Regularisation is a good thing but one cannot change Bye-Laws every five minutes, especially when one has developed a completely satisfactorily operating procedure."

Mr. P. Q. Collins (Member) asked if it was possible to elect candidates at the AGM. In reply the Executive Secretary pointed out that this could be the case if there were no postal ballot. Where there was a postal ballot the ballot papers were, very conveniently, also posted with subscription renewal forms. This allowed an adequate turnaround for 31st Jan. It was very simple, very economical and very effective. Its effectiveness was apparent from the increased numbers of returned votes since the system was adopted: besides that, many members had sent letters of appreciation for the arrangement. "Jan 31st had so much going for it that it was difficult to visualise a viable alternative."

The President affirmed this to be the case since it was very difficult to arrange an AGM that was 13 months after the end of the year considered. The Secretary also replied it was not only difficult, it was illegal, and then summarized some of the legislation problems.

Mr. Collins replied that, perhaps, persuading members to pay twice in one year might "step round" the AGM, the subscription date, and hence the election of new members at the AGM, though the Executive Secretary doubted that members could be so easily persuaded to pay twice: it was often difficult to persuade them to pay once!

He also asked "Do you think that the Candidates should be prepared to turn the whole system (proved by 6 years of operation) upside down simply so that they can be declared Council Members (if elected) specifically at the AGM? What sort of responsible Council Member is that?"

One member said that he had only recently joined the Society and this was his first attendance at an AGM. He felt that "a number of things had been raised such as voting procedure, when Council Members take office, there is the question of the procedure for members to put points of view, make suggestions, propose changes, there is a question of procedures for paying subscriptions, there is a question of 9 months between the end of the year and the date of the AGM for that year. There is a number of questions which seem to me to need to be examined. As I say I am a new member but there are a number of things that need to be tidied up to improve the good name of the Society".

Mr. Lawton did not agree with this interpretation. He had been listening very carefully to the discussion and had only been able to detect 5 (at most 6) dissenting voices out of an attendance of nearly 60 people. "Did this mean that they were representative of the general feelings of the Society. Of course not, the voting of the majority has clearly shown that they are the griping of a small but vociferous group and are not 'questions which need to be examined and tidied up'." He continued: "I would point out that the Society has undergone and is still undergoing major changes. It is no longer an enthusiastic small group of amateurs but a worldwide body of people, professionals and non-professionals alike, who rub shoulders with each other. At last, the BIS has taken further steps along the road to becoming a fully-recognised learned Society and was in the very initial preliminary stages of seeking a Royal Charter. For a body to be professional it also had to be 'seen to be professional' - some members were in very grave danger of missing this point."

He then stated "*You, all of you,* are members of one body and when others speak to you *they will consider you to be the BIS itself.* People will judge the Society by how you behave and what you do. We are growing up. Perhaps these 'gripes' are growing pains but we must grow into a professional society and not allow the break-up of the foundations we have built."

Mr. F. R. Smith objected to being called an amateur. "If that means being enthusiastic then I am glad to be one and I object to what I regard as an insulting remark."

Mr. Lawton replied "I am sorry if that is how you construed my remarks. No insult was intended. An amateur is defined as one who is *not paid* for the work he likes doing. He uses his spare time for his interests. On the other hand, there is a rapidly increasing group of individuals who belong to the Society and who *are* paid for their work and interests and these interests involve spaceflight, satellites, radio communication and a whole host of items bred and generated by astronautics. These are the professionals and receive salaries for what they do.

Some 50 years ago we were largely amateurs. Now we are largely professionals and, properly handled, the Society has a promising future."

With this the President declared the meeting closed.

Concluded from p. 182

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CORRESPONDENCE

Seeking the 10th Planet

Sir, With reference to the lecture of Anthony T. Lawton and Penny Wright concerning the 10th planet mentioned in *Spaceflight* January 1981, it seems to me to be an absolute necessity to inform the members of BIS quickly that an extremely important report was published in *Nature*, Vol. 287 on 25 September 1980. Under the title "Galileo's observations of Neptune", the distinguished scientists C.T. Kowal and S. Drake reported that Galileo observed Neptune on 28 December 1612 and on 28 January 1613 and even noticed its apparent motion!

The position of Neptune for the latter date seems to be of high astrometric value; it is probably accurate to better than 10 arc-seconds. Extremely important is the fact that the observed position deviates by the very large amount of about 60 arc-seconds from the position predicted by the ephemeride calculation model DE-102 of JPL. The authors wrote that this discrepancy may be due to the existence of an unknown perturbing planet.

It should be mentioned that there is a discrepancy in the same direction of 7 arc-seconds between the position of Neptune measured by Lalande in 1795 and the calculated position for that epoch. Neptune was occulted by Jupiter in January 1613; that is why Galileo noticed Neptune. At that time he regularly observed the positions of the four big satellites.

Kowal and Drake outlined that there was a similar occultation in September 1702 and that an examination of manuscripts from that date should reveal cases where Neptune was seen. If positions of high precision of Neptune for that date can be found and if they should show significant deviations from prediction, then there is very strong evidence for a massive perturbing object beyond the orbit of Neptune. Thus, an extensive literature search should begin now. It seems even possible that a recalculation of Neptune's orbit, using Galileo's position, will provide a reasonably small search area for the perturbing object.

If the 60 arc-second deviation derived from Galileo's observation is exact, the object may be as massive as Neptune and should be of about 12th magnitude. An object of such brightness would be in reach for many small telescopes. If the position could be confined to an area of 10 x 10 degrees, the detection of the object may be a matter of some days.

Mr. Lawton wrote an impressive and perhaps fundamental article on "The many shades of the 10th planet" in *Spaceflight*, March 1979. A calculation of the search area by him would be very delightful. A detection of the 10th planet based on such a calculation would be a really historic event.

I give here the mean positions of Neptune for 28 January 1613, 2300 UT, epoch 1950.0:

Neptune ephemeris from JPL DE-102	: $12^h05^m33.3^s$, +0°52'24"
Neptune's position from Galileo's observation	: $12^h05^m30.5^s$, +0°53'11"

DR. NORBERT GIESINGER,
Vienna, Austria.

Dr. Giesinger quite rightly stresses the astrometric value of Galileo's second sighting of 28 January 1613. Galileo was intent on accurately observing and recording the movements of the four major Jovian satellites for use as a unique celestial clock which would enable mariners to determine longitude at sea (a task successfully accomplished some 150 years later). This required precise measurement of the positions and distances of the satellites from the disk of Jupiter. Galileo did this by means of a micrometre disk of paper or card ruled with grid squares, each square representing the disk of Jupiter as seen through the telescope. All measurements were therefore made in terms of Jovian radii, a method which eliminated the determination of siting, setting up and transit timing errors. Jupiter occulted Neptune on January 4, 1613, but since Neptune was obviously in opposition at that time, it remained as a background "star" to the Jovian observations for nearly 6 weeks. Kowal and Stilman Drake (the authors of the letter in 'Nature'*), studied Galileo's work simply because he was the only person making accurate records during that particular occultation. The event of 1702 will require a careful analysis for by then Jupiter was being studied by several workers and problems could arise in reducing their observations to the required accuracy. Galileo's micrometre method was unique in that it was inherently accurate and eliminated the problems of determining setting up errors. This is essential if a meaningfully accurate sighting is to be derived and used as the basis for determination of the perturbation of Neptune.*

In forecasting the most likely position of a perturbating planet one must take full notice of the extremely thorough search carried out by Clyde Tombaugh, not only in his search for Lowell's planet X, but also after he had found Pluto. With his colleague Lampland, this search continued up to 1951. Nearly **45 million** *stars were examined without any further planetary candidates being found although there were several false alarms. A planet as massive as Neptune would have been found and Tombaugh asserted that such a planet would have been revealed at distances over 7 times that of Neptune.*

Several possibilities exist:

(1) The planet lies in a region not covered by Tombaugh's searches. He himself has suggested further search areas knowing that his work was incomplete.
(2) Somehow Tombaugh missed the planets in the area he examined. This is so unlikely it may be ignored.
(3) The perturbation is by an object which is not a planet although it may have a large planet's mass. For example, "Oort's Ring" is a supposition and not yet a proven concept. If this ring were lumpy and non-uniform then it could exhibit pseudo-planetary gravitational perturbation.
(4) The 10th planet is smaller and less massive than Neptune but moves in a highly elliptical orbit.

I favour this last hypothesis which allows Neptune to be perturbed to a high degree by a moderately small planet (3-5 Earth masses) which is now comparatively slow moving. If allowance is made for a dark surface such as possessed by Chiron then the planet could well have slipped Tombaugh's eagle eye. Searching plates for dim, slow moving objects is not easy for outside the plane of the Milky Way the star concentration is over 1,000 per square degree and inside the plane it rises to hundreds of times that figure. And yet one must aim a prediction calculation to approach one degree if there is to be any hope of success. But between now and a successful outcome lies much hard work!

In short, the superbly detailed and accurate notes of Galileo have been splendidly interpreted by Kowal and Drake. Initial treatment of the results only increases my suspicions that the 10th planet is a real object and not the residuals of noise errors on old observations.

A. T. LAWTON,
Shepperton,
Middlesex.

Mr. Lawton was actually in the process of preparing an article on this subject when Dr. Giesinger's letter was received. We expect to publish it later this year. *Ed.*

Space Colony Maintenance

Sir, Mr. Wood has put his finger on the realistic needs of colony maintenance (*Spaceflight*, April 1981). The environment of a colony is meant to be like Earth's, and you don't see airships maintaining buildings down here. Strong "mobile scaffolding" is an essential requirement for both the interior and exterior of a colony, whether in space or on a planetary surface. One might foresee problems with the structural design of the maintenance ring, and with its effect on the colony due to out-of-balance centrifugal forces. More detailed studies should be able to resolve these.

To reduce mass and complexity, one could divide the ring into a number of segments, each confined to its own set of tracks running along the colony skin. A relatively smooth surface would be needed, of course, which requires a re-think on the external slag layer proposed by O'Neill. One large segment could be used internally, much like an arch-shaped gantry crane. This would give rapid access to elevated regions of the roof and walls, an essential requirement for such a vulnerable structure.

The high rotational speed of large colonies may prevent the use of wheeled rings for cancelling motion, but Mr. Wood's scheme would be the basis for a vitally needed transport system. In future, I am sure that all colony designers will adopt Mr. Wood's concept in one form or another.

DR. DAVID SHEPPARD,
Allesley Park, Coventry.

Living in Space Colonies

Sir, I would like to comment on John Allison's thought-provoking letters on "Living in Space Colonies" (April 1980 and February 1981).

I believe that future space colonists would not be removed from any natural wilderness. They will be almost directly in touch with a wilderness greater than all the prairies and forests on Earth: the infinity of space. Of course, they would be confined to a pressurized base, but from every window, what wonders might their eyes meet?

Perhaps I overstate my case. Perhaps a magnificent view cannot remedy claustrophobia born of living in a glorified tin-can for several months. And yet, John Allison suggests that areas of wilderness on Earth are a safety valve for letting off steam by getting away from civilization. Indeed, I often find a walk through the country a relaxing experience. But might not a future (shall we say lunar) colonist find the same true of a walk to (say) the rimwall of Tycho?

An argument against this would be to say that Man could never mentally adapt to lunar desert, and that his eye would always hunger for the green of Earth. Yet, we in Britain regard our countryside as being natural when, in reality, it is as artificial as a factory; it *is* a food production factory. But I venture to say that only a few would seek to change our little bit of "wilderness"!

Perhaps no man alive today could ever feel at home and at one with nature with heavily-booted feet planted in the dust of the *Mare Imbrium*. And yet, the colonists' children, whose spacesuits would be to them as unnoticable as (say) pullovers to us, could well feel differently.

If mankind decides to launch out into the Universe, I would not, in any way feel that the colonists were condemning themselves and their children to a "bland Devil's Island" existence. They would be in a position I envy, at the forefront of human existence, pioneers blazing a trail to the stars.

And finally, would the extinction of *homo sapiens* matter? Very little, probably, in the cosmic scheme of things but who knows what lies ahead? If it be extinction, so be it. But who can but hope, and try for greater things?

GETHYN D. JONES,
Caernarvon, Gwynedd, Wales.

Living in Space Colonies

Sir, In the February 1981 *Spaceflight*, John Allison, in his letter, refers misleadingly to "multiple g" accelerations. In fact the Space Shuttle will only experience about 3.5g, and this for a period of about ten minutes. Future launch vehicles would be even gentler. Under medical supervision certain cardiac patients could endure the short period of moderate dynamic loading, using adrenalin or oxygen if necessary, and intensive care facilities would be available on arrival at the colony. Granted the trip for such patients would be one-way. Still, many sufferers may demand to sign the consent forms, even against medical advice; this is a free man's prerogative.

Agreed, those with normal hearts would be better off in a one-g colony, but the very beauty of colonies is that such environmental factors are entirely under human control, and not nature or the elements.

The matter of the money system is irrelevant; it has been in use in some form for many thousands of years and nobody has yet found a workable alternative. Look what happened when Cambodia recently abolished money. If an alternative to money exists it will not be found until long after the Galaxy has been colonised.

My main point that life in a space colony would not be nearly so dull as John Allison originally claimed still stands.

CHARLES F. RADLEY,
Wherstead, Ipswich, Suffolk.

"Man and the Stars"

Sir, I enclose a cheque from the sale of B.I.S. material at our "Man and the Stars" exhibition here in Hanley, Stoke-on-Trent.

I would like to thank the B.I.S. for all the help which contributed to the most successful exhibition to date in the Museum.

MICHAEL PACE,
Secretary,
Stoke-on-Trent Astronomical Society.

Our Elegant New Headquarters

Sir, I have followed the work which has taken place in forming the new B.I.S. Headquarters with keen interest. The impression I have (unfortunately I have not yet managed to visit 27/29 South Lambeth Road personally) from the photographs and articles in *Spaceflight*, is that an old dilapidated building has been transformed into an elegant, fine headquarters for our Society. The end product will be, I am sure, beyond the dreams of most of us. I would like to put on record my hearty thanks to all those involved in the planning and execution of this project and all members who have contributed by donating to the Development Fund. I am convinced we have something of which we shall be justly proud in the years to come.

My small contribution to the Development Fund is a slight repayment for all that I have received as a B.I.S. member. Through the B.I.S. and interest in Space travel I have had the great fortune to meet some fine people.

J.E. SCOTT,
Littleover,
Derby.

This is one of many letters we continue to receive praising the work of the Society in establishing our new Headquarters Building. The effort is now underway to raise the money to repay the £30,000 Bank Loan which covered the final construction cost. All donations should be addressed to Mr. L.J. Carter, Executive Secretary, British Interplanetary Society, 27-29 South Lambeth Road, London SW8 1SZ. Ed.

NOTICES OF MEETINGS

Film Show
Theme: **THE MAKING OF AN ASTRONAUT (PART 1)**

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **20 May 1981**, 7.00-9.00 p.m.

The programme will be as follows:
(a) Flight of Monkeys and Mice in an Aerobee Rocket

(b) Fluids in Weightlessness

(c) Science Reporter - Suited for Space

(d) Project Gemini Test

(e) The Four Days of Gemini 4

(f) Legacy of Gemini

The programme will be repeated later, if warrented by demand.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Title: **PLANET 10 - THE GIFT FROM GALILEO**
by A. T. Lawton

The theme is based on a very recent discovery that Galileo saw and recorded the planet Neptune in 1612.

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on: **27 May 1981**, 7.00 - 9.00 p.m.

Technical Forum

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 on Friday **29 May 1981**; 6.30-9.00 p.m. and Saturday **30 May 1981**, 10-12 noon and 1.30-3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet Space Programme are invited to attend. A registration fee of £1.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

Lecture
Title: **SPACELAB**
by Dr. M.J. Rycroft

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on Wednesday **3 June 1981**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Open to members of the Society both in the UK and USA

SOLAR ECLIPSE JULY 12 - AUG. 2, 1981

The Southern California Branch is organising a group expedition to view the solar eclipse on 31 July 1981. The tour will include visits to many astronomical, archeological and historical sites leaving by air from London to Peking and travelling by rail through Ulan Bator and Irkutsk to Bratsk, where the group will view the eclipse. Return will be through Moscow.

Arrangements will be in the hands of Mr. R.V. Frampton, Mail Stop 264-519, Jet Propulsion Laboratory, Pasadena, California 91103, USA.

Members interested should contact Mr. Frampton for further details.

Total cost from London will be about £1560 ($3595)

Lecture
Title: **The ARIEL 5 and 6 EXPERIENCE**
by Dr. M.J. Ricketts

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **2 September 1981**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

32nd IAF Congress
The 32nd Congress of the International Astronautical Federation will be held in Rome, Italy from **6-12 September 1981.**
The theme will be:

SPACE: MANKIND'S FOURTH ENVIRONMENT

devoted to "promoting awareness about the challenges and debating the problems posed by the use, further exploration and management of this fourth environment." The theme will then be developed through a series of symposia and technical sessions organised by the IAF and by the International Academy of Astronautics (IAA).

36th Annual General Meeting
The 36th Annual General Meeting of the Society will be held on **26 September 1981**

Details of the Agenda and Venue will appear in *Spaceflight* shortly.

Nominations are invited for election to the Council. Forms can be obtained from the Executive Secretary. These should be completed and returned not later than 3 July 1981.

First Night
An opportunity for new members of the Society (and interested guests) to meet members of the Council and Officers of the Society will occur on **7 October 1981**, at the Society's HQ Building, 27/29 South Lambeth Road, London, SW8 1SQ, 7.00-9.00 p.m.

It will be an informal evening in which members can hear about the History and Activities of the Society, see a space film and have an opportunity for a short guided tour of the Building.

New members who would like to attend are invited to apply in good time, enclosing a reply-paid envelope.

Lecture
Title: **RECENT ADVANCES IN SPACE FLIGHT**
by P.S. Clark

A review of space activities throughout the world which have taken place during the past twelve months, to be held in the Golovine Conference Room, Society HQ 27/29 South Lambeth Road, London, SW8 1SQ, on **14 October 1981**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture
Title: **OBSERVATIONS OF THE ATMOSPHERE OF VENUS FROM THE PIONEER ORBITER**
by Dr. F.W. Taylor

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **18 November 1981**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Continued on back cover

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Continued from inside back cover

Film Show
Theme: **THE MAKING OF AN ASTRONAUT (PART II)**

Further stages in the development of manned space voyages will be illustrated in the following film programme which will be screened at a meeting to be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **2 December 1981**, 7.00-9.00 p.m.

The programme will include the following

(a) The Hard Ones

(b) Gemini 11 - Quick Look

(c) Spaceship Skylab - Wings of Discovery

(d) The Mission of Apollo-Soyuz

(e) Space Shuttle - Overview

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture
Title: **STARS — THE SOURCE OF LIFE**
by C. A. Whyte
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **18 January 1982**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture
Title: **THE RETURN OF HALLEY'S COMET**
by M. J. Hendrie
To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **10 February 1982**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show
Theme: **SPACE SATELLITES**

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **24 February 1982**, 7.00-9.00 p.m.

The programme will include the following:

(a) Landsat: Satellite for All Seasons

(b) Navigation Satellite Project

(c) Discovery in Space

(d) Streetcar (OGO)

(e) Electric Power Generation in Space

(f) Orbiting Solar Observatory

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Symposium
Theme: **SATELLITE FLIGHT DYNAMICS**

A two day Symposium will be held in the Rutherford Appleton Laboratory lecture theatre, Chilton, Didcot, Oxon on **3 - 4 March 1982.**

The Symposium will include the following topics:

1. Orbit determination and prediction techniques
2. Attitude control systems
3. Modelling of the space environment
4. Satellite dynamic behaviour
5. Satellite control and stabilisation
6. Large flexible arrays
7. On-board computers

If the response is sufficient, the symposium will be extended to a third day (5th March 1982).

Offers of papers are invited. Registration forms and copies of the programme will be available from the Executive Secretary in due course. Please enclose a stamped addressed envelope with request.

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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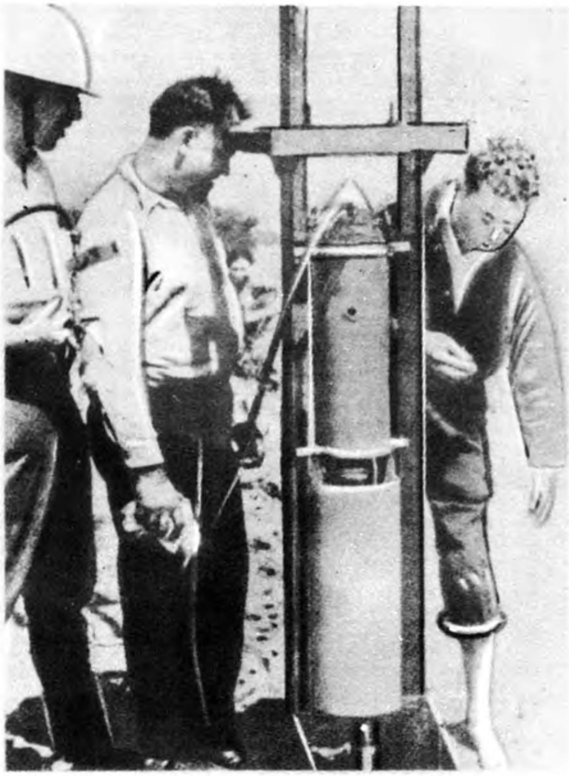
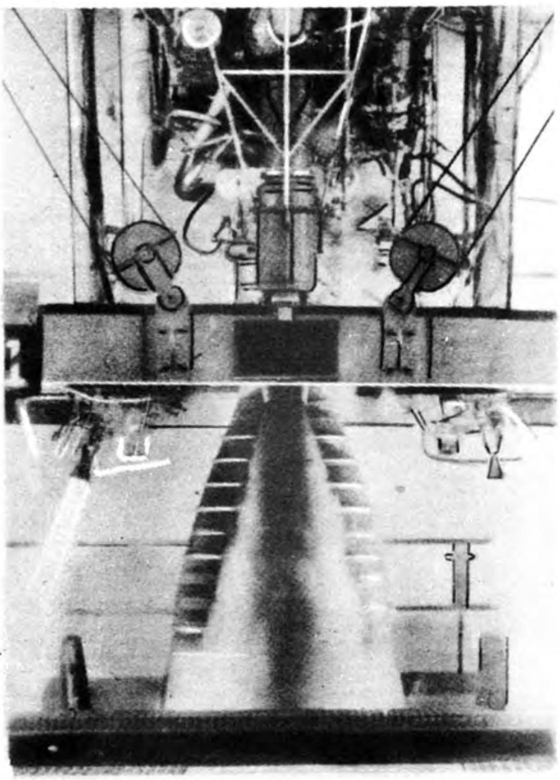
SPACEFLIGHT

VOLUME 23 No. 7 AUGUST–SEPTEMBER 1981 Published by The British Interplanetary Society

The Council, Officers and Members of the British Interplanetary Society offer CONGRATULATIONS to the AIAA on its



50th ANNIVERSARY



The American Interplanetary Society, later called the American Rocket Society (ARS), was founded on 4 April 1930.

The Institute of the Aeronautical Sciences (IAS), later called the Institute of the Aerospace Sciences, was founded on 1 October 1932.

On 1 February 1963 the ARS and IAS merged to become the American Institute of Aeronautics and Astronautics.

BINDERS FOR JBIS & SPACEFLIGHT

The Society can now provide Easibinders capable of holding one complete volume, i.e. up to 12 copies either of *Spaceflight* or *JBIS*. The binders are loose-leaf, so magazines can be filed away shortly after receipt or extracted again for easy reference if required.

Each Easibinder will be supplied with the appropriate title of the magazine gold-blocked on the spine and be packed in an individual carton. The year and volume number will be supplied as individual stickers of gold-leaf Letraset and need simply to be rubbed on to the appropriate square on the spine.

The covers for *Spaceflight* are blue, for *JBIS* green. These are the standard colours adopted by the Society for many years now. The binders are available at £5.00 ($12.00) each post free. Members ordering should indicate the magazine for which the binders are required and state which years(s) and volume number(s) are needed. Volumes immediately available are those for the years 1978 to 1982 but stickers for earlier years can also be supplied on request, though these may be subject to slight delay.

Orders and remittances should be addressed to the Executive Secretary British Interplanetary Society Limited, 27/29 South Lambeth road, London SW8 1SZ.

NEW...NEW...NEW

In view of the continuing popularity of our range of T-shirts, the Society is now introducing a good quality **SWEATSHIRT.**

Available in Small, Medium, Large and Extra Large sizes, the Sweatshirt is Navy Blue with a 3 inch diameter pale blue BIS logo on the left upper chest.

Price is £7.00 ($16.00) post free, available from the British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ, England.

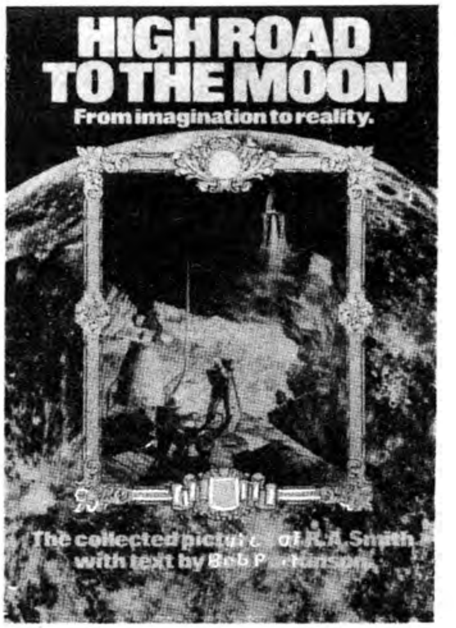
TWO IMPORTANT SOCIETY PUBLICATIONS

One of the Society's most recent projects is a series of Reports on subjects of particular interest to members. Two have been published so far:

Project Daedalus, contains 24 papers which summarise the work of a four year study for a Starship Probe to Barnard's Star. Organised by Dr. A.R. Martin and Alan Bond. It runs to 192pp. The cost is £6.00 ($15.00) post free.

Front cover of 192pp Deadulus Final Report, published in 1978 and now available again with a 2nd impression in 1981.

High Road to the Moon, by Dr. Bob Parkinson, records many of the Society's original ideas and discussions on Lunar exploration in the visionary drawings by the late R.A. Smith. These pictures depict ideas on orbital rockets, space probes, ships to take men to the Moon and beyond. The book contains 120 pages and about 150 illustrations and text. It is available for £6.00 ($15.00) post free.



Front cover of the 120pp *High Road to the Moon*.

pointing toward the pad and beside it, the word "Launch". I was told that somebody in the NASA public affairs department worked up a press release which began "The trouble-plagued and much delayed ABC building suffered another costly setback". It was a parody of several ABC reports on the Shuttle. It was rumoured that the remodeling cost something on the order of $300,000. Trailers for UPI, AP, Mutual Radio, the BBC, Western Union, European Radio Network and Voice of America are arrayed behind the network buildings. The Cable News Network has its own truck-mounted satellite transmission station. Local TV station relay vans are in abundance and personnel with mini-TV cameras scurry about while technicians unpack trucks and hook up cables.

At the NASA press centre, reporters crowd the building. NASA and contractor personnel man the long counters to deal with inquiries. More than a few of the reporters are starting to feel a little lost. Off the main area is the news release and 'phone room where the walls are lined with shelves holding news releases from NASA and contractors. On the floors are boxes of even more. Boeing, Martin-Marietta, Sperry, McDonnell-Douglas and the Air Force are all represented. A woman from Rockwell International is passing out plastic carrying bags to hold all of the 'goodies'. The central table fills most of the room, its top cluttered with even more press releases, ash trays, and an occasional candy wrapper. Reporters, 'phone credit cards in hand, clustered around the 'phones dispatching stories and passing on the latest news. The place is a crossroads for the assembled press.

The press facility, next door, is for photo and TV services arranging tours and interviews. There are three tours leaving daily. A 10 am tour of the Pad 39 area and the Air Force Station; a 1 pm wildlife tour and a 2 pm orientation tour of the Pad 39 area and the Spacelab complex. Amid all of this activity, perhaps the only area quiet for somebody to collect his thoughts is the press grandstand. It resembles a large grandstand one might find at a racetrack. It overlooks the barge turning basin and floating there is a mock-up of the Space Shuttle nose. Earlier that day, a recovery exercise had been run using it. The countdown clock is now still. The large circus tent for working press is deserted.

When seated in the stands, the VAB is on the far left. A little left of centre is Pad 39B, its service tower in place but empty. Directly ahead is Pad 39A, the centre of this mini-universe. Only the top of the External Tank and solid rocket boosters are visible. The Orbiter itself is hidden by the changeout room. Off to the right is Titan III, Pad 41. All the other pads are hidden behind a large grove of trees. At T−2 days only a few reporters and NASA technicians are present.

At 2 pm we take the bus for the pad tour and only a few of the people aboard have ever attended a launch; less than one-third.

We come to the two parked crawlers. The NASA guide describes their features. One mile per hour loaded, two miles per hour empty, each tread weighs one ton, its mileage is a truly awe-inspiring 150 gallons/mile. Its exhaust underneath is as long as a car. The bus continues until it reaches Pad 39A. The guide explains that, to fuel the Shuttle, a small amount of hydrogen in the liquid hydrogen tank is allowed to vaporise and the pressure is enough to force the lightweight liquid into the External Tank. The tall insulated rod, atop the launch tower, is connected to long wires to carry away any lightning bolts that might strike the pad. The bus finally stops at the regular photo viewing area and we get out. All of the External Tank and Solid Rocket Boosters are visible. The changeout room covers the Orbiter and only the wingtip is visible. After taking pictures, the passengers start to drift back. The bus driver honks his horn to urge on a few stragglers.

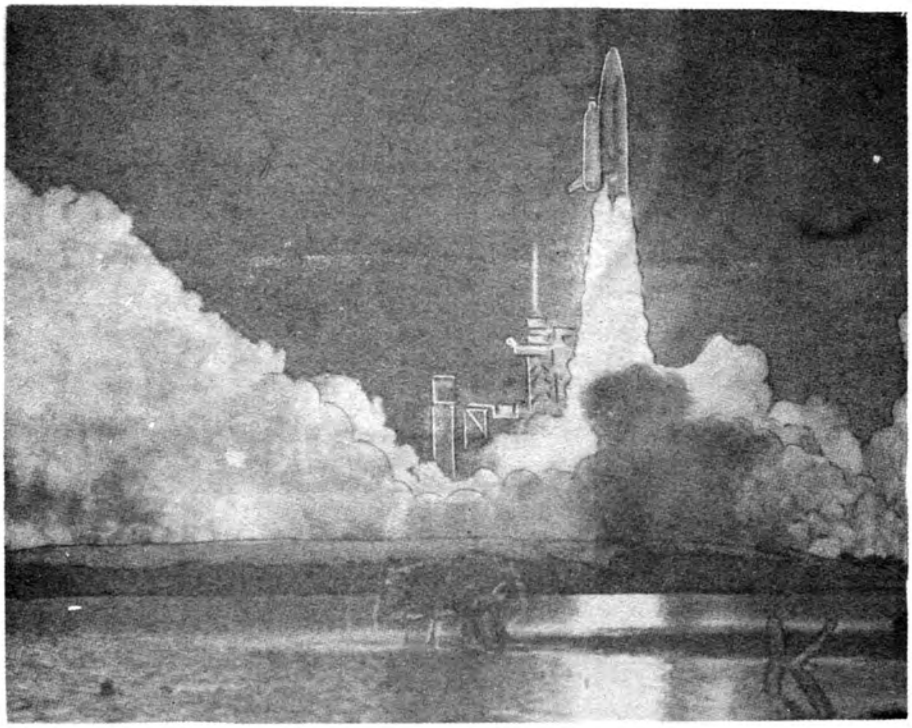
After the bus starts again, the guide explains that the changeout room blocks the view of the Shuttle from the press site (it was not designed from the public affairs point of view, he notes) although it does not really matter since the steam from the sound suppression system would hide it anyway.

The guide also talks about the tiles (crew very confident); the cost (0.8 cent of every tax dollar) and expendable boosters (Titan 34-D for the Air Force, Deltas for NASA and the Atlas Centeur to be phased out in about 1984). We continue past Mission Control and the VAB. Parked near it are two mobile launch platforms, one modified for the Shuttle, the other left, for now, in the Apollo/Saturn 1B configuration (it had been used for ASTP). The bus then goes to the Shuttle runway and we are told that one peculiarity is that the runway tends to create its own weather because of reflected sunlight.

Returning to the press centre, we drop off a few people and the second part of the tour starts. It takes us to the operations and checkout building. Here, in the long ago days of Apollo, the CSM was prepared for launch. At present, it serves the same function for Spacelab and as home for the astronauts. Young and Crippen had flown in earlier that morning and were now on the third floor. Although we do not have to don white coats and hats to see the Spacelab Engineering Model, we do use a shoe cleaner. The three brushes feel as if they are trying to remove our shoes. With clean shoes, we are admitted to the high bay area. It is a clean room with the solemn air of such places — large, quiet and well-lit. We are first shown a pallet on its alignment railing; the McDonnell-Douglas employee explains that this area is used for experiment integration.

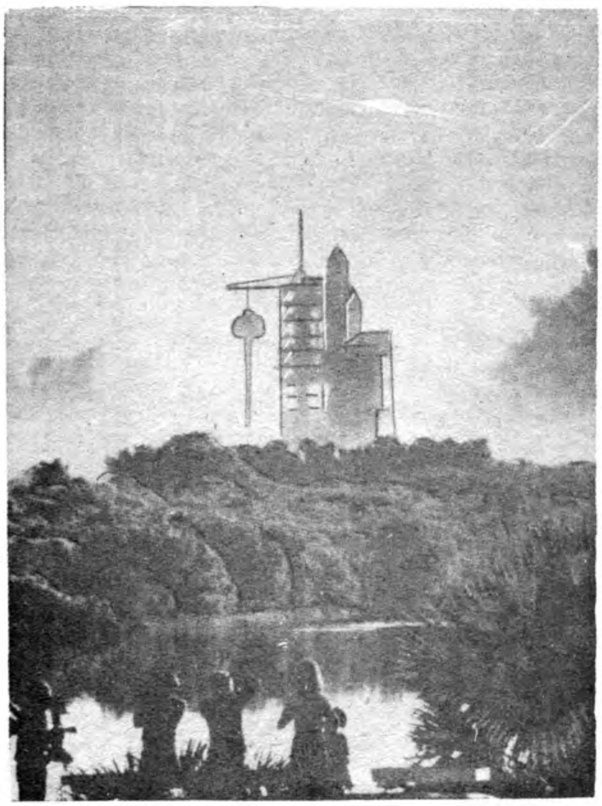
Climbing up a ladder, we get a close look at the Laboratory Module. The flooring and empty equipment racks are in place and on the lower front part support equipment is mounted. One cylinder is tagged "critical item". Also, there are the

Left: the press stand at the Cape, equipped with TV monitors, telephones and power for radio broadcasts. *Right:* inside the NASA news centre.



Left and below: Columbia lifts off on 12 April 1981, 20 years after Gagarin's brief space trip. Young and Crippen reported that vibration was no problem - instruments appeared slightly blurred but they could be read. Ice from the External Tank continually broke away and impacted against the windows.

prospective payload specialists who answer our questions. Further back, in the bay, was the pallet outfitted for the second Shuttle mission. Much of the equipment is carefully covered with plastic; several avionics boxes are mounted to the pallet and wire bundles run everywhere. On the left side of the pallet there is a shelf with several Earth survey and resource experiments mounted on it. On the other, is the Shuttle imaging radar unit; a long flat plate on a rigid tubular mounting. The unit is similar to that flown on Seasat, only larger. The pallet is mounted on a jig unit that structurally and electronically matches the Shuttle payload bay and aft deck. The hardest part of the process is alignment; the rails they are bolted to are much larger and thicker than those of a railway.



On the ride back, the guide talked about future plans, noting there is considerable pressure on the Reagan Administration to approve the development of a permanent manned space station. The most likely would be a joint NASA/Air Force facility in polar orbit. Also, the reporters are given an introduction to Cape wild life. The guide points to a tree that is home for a pair of bald eagles.

As the day ends, the news has improved; the weather, which once seemed threatening, is now clear, and no problems have appeared in the Shuttle.

April 9: launch draws closer

As we drive to the Cape we note more signs, carrying such messages as 'California or Bust, Go Columbia', 'Welcome Space Shuttle Fans' and 'Go, Columbia, Go'.

After we park, a public address call from the VAB goes out for Guenter Wendt, the man responsible for the checkout of almost all manned spacecraft back to the days of Mercury.

At the press centre, there is a slight but noticeable increase in activity. Four reporters are here from *Aviation Week & Space Technology*; photographers are starting to set up their tripods by the edge of the turning basin — a territory to be defended against all comers. An interview is underway in front of the grandstand. The countdown board reads −12:00:00 and holding (it is a preplanned hold). The count will be resumed in the afternoon and meanwhile there are no problems and no major activities on the pad.

Earlier that day, the astronauts had practised landing approaches while bird watchers monitored the location of soaring birds in order to warn of any potential bird strike danger.

On our 10 am drive towards the pad, we passed one of the crawlers being 'exercised'. Like a car, they must be used

occasionally to keep them in good running order and this one has just had a new set of treads fitted. The old ones had been worn out carrying the Apollo boosters. It has travelled some 400 miles on this road to the Moon. The crawler moves with a certain ponderous grace — slow and deliberate. One can see how the mobile launch platform is made mobile.

After a false start, we are able to get even closer to the Shuttle than the day before. We stop near the perimeter fence encircling the pad complex and a TV reporter films a 30 second 'standup' with the Shuttle as a backdrop while we take pictures. The changeout room is swung back revealing, for the first time, the entire Shuttle Orbiter and the tiles are clearly visible through binoculars. The Orbiter is a glossy white. The External Tank and Solid Rocket Boosters are a flat, perhaps creamy, white; not sleek but it has a functional beauty. Its aerodynamic shape is in contrast to the building-like launch tower. The dream given physical form. In a few hours, this area will be battered by an unimaginable violence as the Shuttle heads for space. Here, almost in its shadow, more than a few of the reporters would like to make that trip.

The second half of the tour is a visit to yesterday: to the old pads in the original part of the Cape Canaveral Air Force Station. Our first stop is at the Air Force Space Museum. We get out at Complex 5/6 to look at the now primitive Mercury Redstone, a tiny pencil set upon an inadequate-looking stand. The blockhouse with thick concrete walls and armoured picture windows overlooks the pad.

We continue our tour of the old pads. At Complex 14, the Mercury Atlas pad, all of the metal gantry has been removed and only the blockhouse and concrete ramp is still there. The place has an air of desolation like the sunbleached buildings of a desert ghost town. The concrete is stained and worn, with a monument at the base of the ramp. No funding has been provided for maintenance, nor would it be practical with the Cape's very high content of salt in the air. Next is Pad 19, site of the Gemini launches, two of them with John Young aboard. The erection tower is on its back, now immobile; the holdown arms are still in place above the rust-streaked flame pit. The umbilical tower has been removed. "Abandoned in place" is stenciled on the buildings. After this, we see Pad 34, site of the Apollo 204 fire. The pad area itself is closed off, a place that once saw such activity now serves as a home for abundant rattlesnakes. Weeds are growing along the edge of the blockhouse roof.

The Shuttle appears from behind the tall brush. Near the perimeter road, people are setting up remote cameras to photograph the liftoff. Activity at the press site is beginning to increase — more vans and people. The bus has difficulty manoeuvring through them. Outside the gates, the crowd has started to gather; motor homes crowd the water's edge at each end of the Bennett Causeway and boats sail back and forth in the Banana River. Restaurants have organised special pre-launch breakfasts at 4 am. This is the atmosphere newspaper editors seem so interested in. For many old time residents, it brings back memories of the 1960's.

More serious questions are addressed at a press conference in front of the grandstand. Attending are Yardley, Page, Slayton and an Air Force weatherman. One reporter asked what would constitute a successful mission; one of them responds that he would be satisfied with all three landing gear intact after touchdown. Yardley says that the destruction of *Columbia* would put the programme back two years but would not mean its termination. Another reporter asked what the crew would be having for breakfast. Another asked who would decide, in the event of an abort, whether the Shuttle would come down in a foreign country (the crew and mission control). Another wanted to know if the Russians would be asked to help if the Shuttle could not return (No). A reporter wondered if the anti-nauseous pill to be taken at T+30 minutes was optional. (Young had never had a problem so he would not take one. Crippen, however, would because this was his first spaceflight.) A long rambling question about the meaning of it all drew smiles. An Australian reporter wanted to know if the External Tank could impact on Australia; he was assured that, even if it overshot, the inclination of launch was such that it would come nowhere near Australia.

April 10: launch day

It is still the waning hours of April 9th when we start out for the Cape. As we drive through the darknessnothing except an occasional sign gives any indication of the monumental event happening nearby. But as we cross the Indian Riverwe see the searchlight beams from the pad. They stand vertically like a comet, its tail extending into the sky. On the road in to Gate 2, traffic flow is normal; no stopping at all — just another rural Florida road. Then a few hundred yards from the gate, a line of trucks, vans and cars loom out of the darkness parked by the side of the road. Standing by the vehicles or sitting in lawn chairs by campfires, the spectators are gathered. At the press centre, reporters are watching a news programme on the Shuttle. In the press grandstand, the seats are starting to fill. Photographers and their tripods line the banks of the barge canal. An occasional flashlight beam shows their position. Another line is immediately in front of the grandstand. The TV monitors show different views of the Shuttle and Mission Control. Lights from the various facilities stretch across the horizon and the pad itself is caught in the glare of the spotlights. The External Tank is a brilliant white, it seems almost self illuminating.

The countdown clock is running, measuring the time remaining until launch. We arrived at about the time fuelling had begun and the PA system gives periodic announcements as the fuel level increases. The planned hold at T−2 hours, 5 minutes comes. Shuttle Control announces that there is a minor leak in the hydrogen umbilical line — it appeared during the previous fuelling and the technicians are working on it. Just after the hold is called, it is announced that the crew was awakened an hour previous and are now being served breakfast. One reporter comments that Crippen looks good at 2 in the morning; smiling as the camera observes him eating breakfast. Young has a sombre expression.

At the grandstand, the assembled multitude mills around. Reporters there are surrounded with cameras and recorders, while others nibble on snacks. Some type their stories on complex machines ranging from simple typewriters to word processors. A few complain about the parking or releases. Mosquitoes attack everybody without regard to importance.

The TV shows the closeout crew working on the Shuttle and the PA announces that the hydrogen leak has been corrected. Applause. Next the TV shows the crew suiting up, adjusting their gloves and helmets, and Young slips his glasses into a suit pocket. There are announcements about a leak in Crippen's helmet and the changing of a microphone but the delay lasts only a few minutes. Smiling, the two depart the astronaut quarters and enter the transfer van while the TV cameras follow their progress through the centre. Then a line of vehicles, with flashing blue or red lights, appears around the corner of the grandstand and travels by the VAB and then down the crawler way. Data on weather, cloud cover and winds aloft are all satisfactory as are conditions at the various landing sites. As the crew reaches the pad the countdown resumes. The TV monitors show the crew in the white room. Young, then Crippen, crawls into the *Columbia* and voice transmissions from the crew begin to be heard as they are strapped in and the suits are tested. Finally, at just over T−1 hour, the hatch is closed. By this time, the sky is beginning to brighten and off in the distance is a bank of grey clouds. The crew and controllers are busy aligning the guidance platform, venting cabin pressure and performing other checks. For many in the grandstand, there is now little to do. The newspaper reporters have deadlines but the magazine and free-lancers can only wait. To

fill air time, a TV reporter begins interviewing foreign journalists — an Arab, in traditional headdress, and an Austrian radio anouncer.

The arrival of Governor Jerry Brown of California and ex-astronaut Brian O'Leary (selected in 1967 — Ed) is an open invitation to the press to descend like locusts. The reporters cluster four deep around them, taking pictures and asking questions. Soon after, the crew announces an increase in oxygen content in the aft compartment and the engineering staff begins to work on the problem.

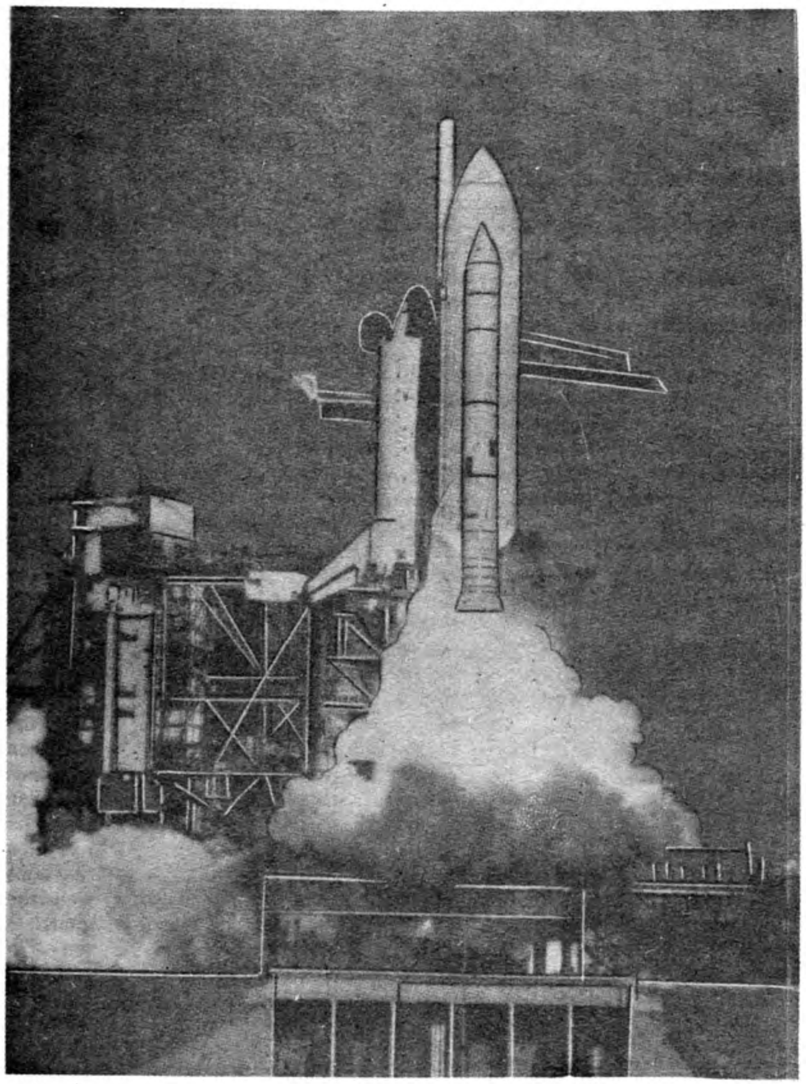
For many reasons, the launch is reminiscent of the Mercury Redstone-3 flight. Like it, the Shuttle is a complete departure from previous vehicles. Another is that most of the reporters have never covered a flight. This is a new and novel experience outside their previous work in journalism since it has been, after all, almost six years since something like this has happened. It is almost like starting over again.

At the T−20 minute programmed hold, new weather for the landing site is updated. Now the grass area is covered with people and every imaginable camera, lens and tripod combination. Looking back at the grandstand, one sees a field of magnified eyes peering at the launch pad through binoculars and cameras. The PA announces during the hold that the oxygen level in the aft bay is deemed to be no problem.

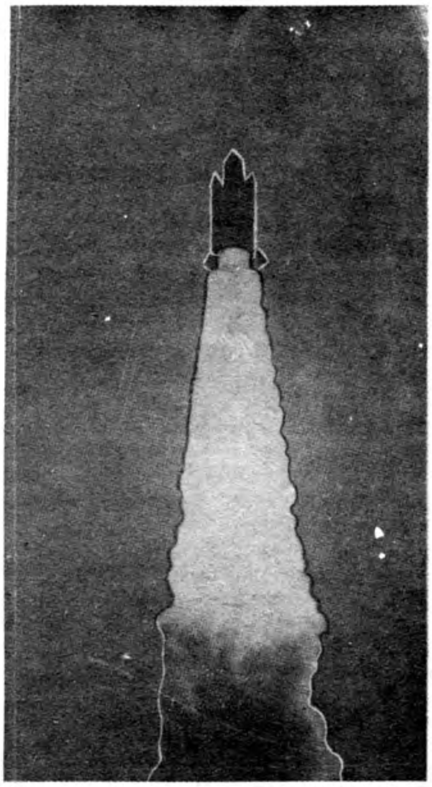
The Dryden Flight Research Center, even then, was getting ready to receive the vehicle. The Sun has risen above the horizon, a hot golden yellow. At the Control Center, there is a check of readiness to resume the count. When it is, the tension starts to build.

At T−1 day, one is overwhelmed by the glory and adventure of it all — these men in this vehicle about to set sail on the infinite ocean. In the cold light of the launch day dawn, one must face the awesome realities of the event. There are few things more irrevocable than a rocket launch. The PA announces that there is a problem in the computer comparison tests but at the T-9 minute hold it announces that the problem has been successfully rectified. Applause from the crowd.

Breathing becomes more difficult. The tension starts to get to you. The PA announces that a warning light has come on, there is a problem in the p.H. level in fuel cell 3. The hold is extended. The crowd groans. The problem is caused by excess water production and the launch team is looking into it, discussing it back and forth with the crew. Reporters work feverishly trying to update the story minute by minute. By now, the sea haze is starting to dim the image of the Shuttle through binoculars. The fuel cell problem is deemed to be acceptable but the problem in the computer has not gone away, however. The computer program is dumped and re-programming has begun. A comparison of the two programs is underway but it does not look good. Hold capacity is running out — they can delay the launch only so long. While the crew is running through the switch sequence, the public address system clarifies



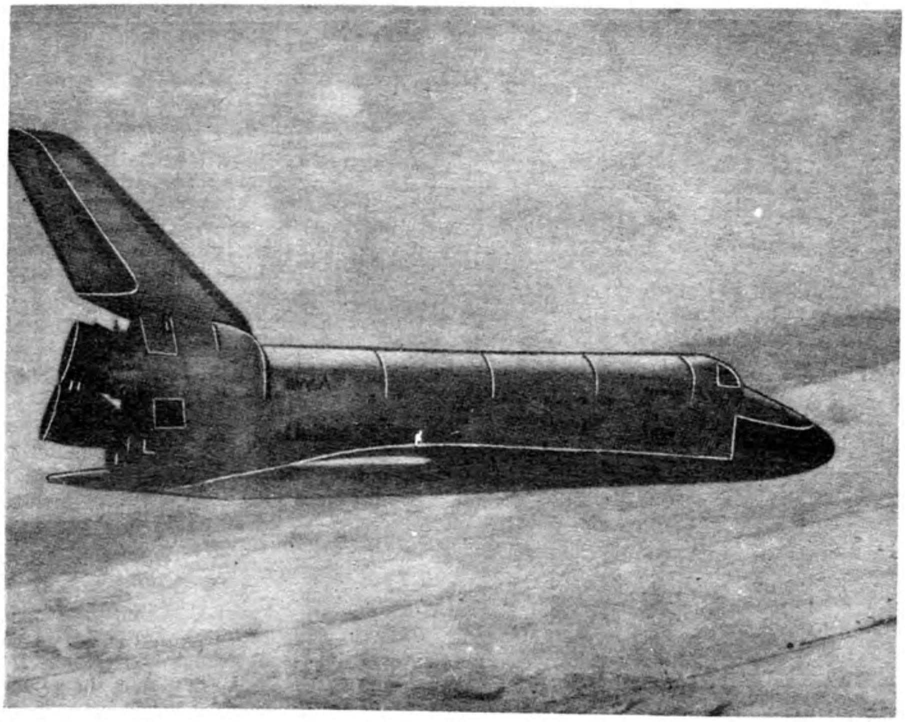
Two further views of the beginning of the STS-1 mission. Visibility was so good that SRB separation could be seen from the ground.



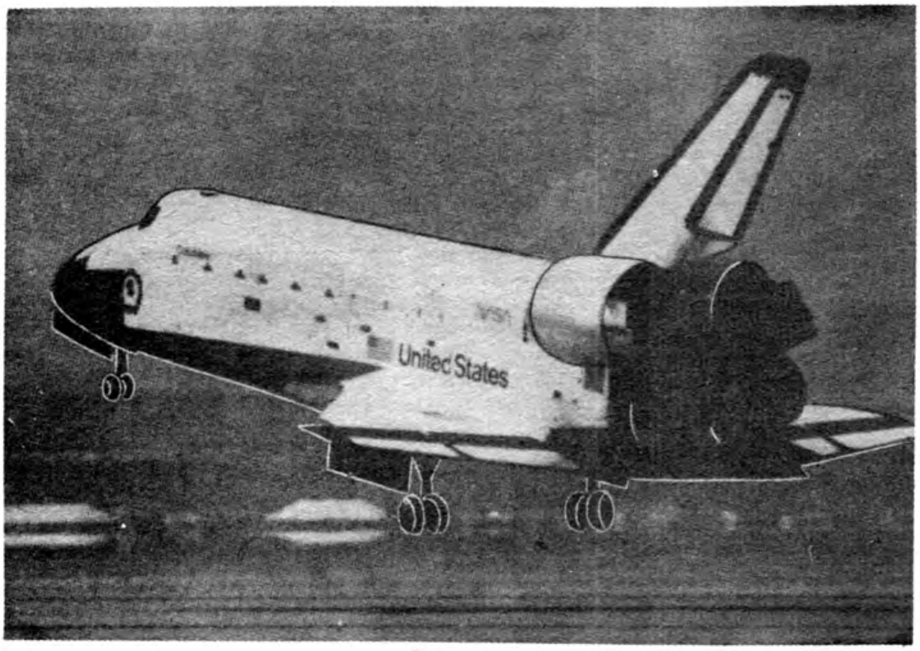
the situation: the inertial platform would have to be realigned, causing a recycling of the count to T−51 minutes. The tension is increased by the fact that each statement is begun with "This is Shuttle Mission Control, an announcement follows in thirty seconds". We try to listen to the *Columbia*/Houston conversations but they are technical and we do not have enough data or knowledge to fully interpret them. We have no more success controlling our emotions as the hold drags on and on. From the conversations, it looks as if the count will have to go back to T−51 minutes but then there is some mention about T−20. The PA announcement clarifies the situation. The count will go back to T−20 minutes in preparation for a realignment of the platform. Alignment is normally done at T−51 but it can be done in the new time frame. The clock now reads T−23 minutes. After a long time, the clock begins counting and sends a ripple through the crowd. The PA simply says that they are just running the clock back. They further explain the launch limitations: the astronauts should not spend more than six hours in their seats and 20 hours between wake up and the first sleep period. When the announcement comes that the part of the failed software in the computers has never been run before, it brings cries of surprise from the gallery. The 30 second announcement heightens the suspense. The public address system says that the fifth computer is not communicating properly with the other units and testing is underway to see if the problem is with the computer. A slip by the PA about whether to set a new launch *date* instead of *time* brings groans. All hope of a launch seems lost. The delay will be over an hour. The reporters have to write and re-write as each new announcement is made. And then, with no announcement, we see the clock starting to run at T−51 minutes and counting. When the PA announces that the count has been resumed, a cheer goes up. The count runs to T−20 minutes for a hold to complete alignment of the inertial platform, estimated to take 30 minutes. Houston continues to troubleshoot the problem and the count resumes to yet another cheer. Then, at just over T−16 minutes, the problem recurs. Twice there is a 30 second warning. At T−12 minutes, the announcement that a scrub is being contemplated. At T−10, the formal announcement is given. There is, as yet, no determination if it is a software or a computer problem but it has become too late for another attempt this day. Because of the de-tanking and purge procedure, it will be Sunday before another attempt can be made. Ironic applause greets the message. It is not yet 10.30 am, yet it seems like late afternoon. The roller coaster of events, the disappointment of the scrub and some 30 hours without sleep crush the spirit. Only the launch team and the crew seemed unperturbed. At one point that long morning an unknown voice came over the net and said "the reason they are delaying the launch is so we can get the burritos on board." This day's events are now over.

April 11

Today the consequences of the scrub must be faced. For NASA, it means finding the solution to the problem. During the night, it had been determined that it was a timing problem between the computers. For the assembled multitudes, it was necessary to change airline tickets, hotel and rent-a-car reservations. It also provided a chance to catch up on sleep. At noon the problem is solved and the count is on.



***Columbia* heads for Runway 23 on Rogers Drylake of the Dryden Flight Research Center. The next two missions will use this area but the fourth may be redirected to a landing on the concrete runway at Canaveral.**



Seconds to go before the 200 mph touchdown. Some discolouration can be seen at the base of the tail but, otherwise, *Columbia* looks in perfect condition.

April 12

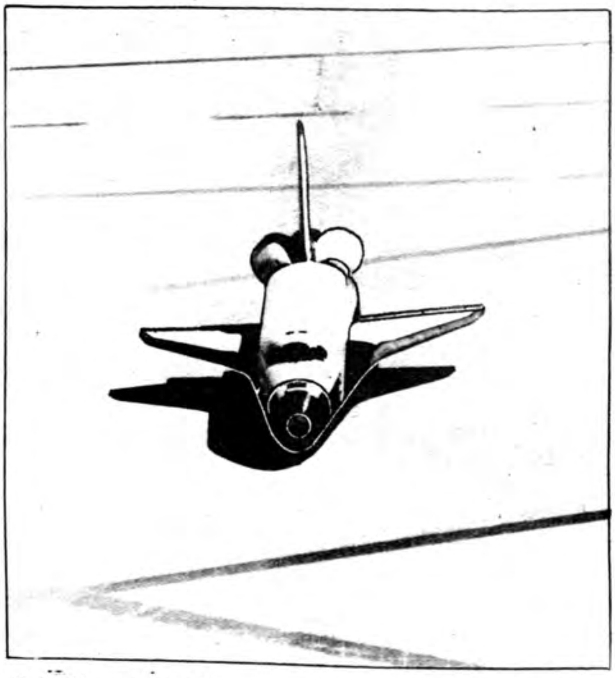
It is 12 April 1981; twenty years ago today, the age of manned spaceflight began. Major Yuri Gagarin made the first human voyage beyond the Earth and if all goes well the second space age will begin today. Once more the drive from Melbourne to the Cape. There is still no traffic. The filling of the External Tank is going smoothly. At the news centre, I meet several BIS members and we adjourn over to the news facility and watch the two big TV screens which show the launch preparations. Indoors we are away from the ever present mosquitoes. The PA announces at T-2 hours and 9 minutesthe waking-up of the crew. The weather reports, which looked so threatening the night before, have now cleared - the cloud cover never materialised. As before, films of the crew eating are shown and watching two people eat breakfast this early in the morning is both amusing and a little embarrassing. They endure the invasion of privacy by a cameraman. They wear the same expressions: Young looking off into space, his face mirrored in intense concentration; Crippen smiling.

During the hold, the crew moves to the suiting room and to fill the time the public address system explains how, because of computers, the launch crew could be much smaller than for Apollo. There seems to be some indefinable difference in atmosphere. Everybody seems more confident. On the 10th, everybody seemed on edge. Perhaps because we are all 'veterans' now. We have all been through the countdown before, at least up to T−9 minutes. The TV screens next show the crew being suited up, loading stuff into their pockets. Young; wearing glasses, is putting on his helmet. The crew, now suited up, walk out to the van for the drive to the pad. I move out to the grandstand. Soon after comes the convoy of flashing blue and red lights. Aboard the Shuttle, an oxygen flow problem is quickly fixed by one of the support astronauts.

As the sky starts to brighten, the closeout crew completes its tasks. They check the seal of the hatch, close it and fit the tiles. The conviction builds that this will be the day.

There is slight applause as the count goes below T−1 hour. At T−57 minutes, calibration of the aerodynamic experiment is done. The stars begin to fade, replaced by a pale blue sky and salmon-coloured clouds. At T−51 minutes, they announce that the weather is perfect for launch, and the schedule is coming up on platform alignment. A thin ground fog covers the surface of the turning basin. On the TV screens, it shows the closeout crew removing the seal between the white room and the side of the Orbiter. We wait for the weather check on the landing sites and the countdown approaches the point where the problem which ultimately scrubbed the first launch attempt appeared. As before, the butterflies start to take wing and somebody walks by with a T-shirt carrying the message "STS-1 Take 2".

There are rumours in the crowd that the Russians will launch a winged vehicle at this hour. The T-20 minutes hold comes; no problems have appeared. The hold approaches its end and the point will soon be reached where Friday's failure occurred. The PA announces that Dryden is getting ready. The launch director gives the go-ahead for the countdown to resume and there is applause as the clock again ticks away the seconds. The



Columbia comes to rest

computer programs are being compared and then it is announced that they are all functioning properly. A bigger cheer goes up. The clock winds down to the T−9 minute planned hold; the beany cap lifts from the External Tank and then retracts. The Control is discussing launch commit criteria and Launch Director Page reads a message from President Reagan to the crew. The PA announces that the count will resume, the clock starts and there are even louder cheers and yells. The swing arm moves back at T-7 minutes. The crew lower their visors. The PA announces "go for APU start," there is light applause, and the APU starts. It is unimaginable that anybody could actually get used to this! The control surface movements are checked. The vehicle is now running on internal power. There are cheers at T-2 minutes. The seconds start to slide past, heart rate increases, the stomach tightens. Louder applause at T-1 minute. At T-37 seconds, I drop the notebook onto the wet grass and start looking through the binoculars. The last seconds are rushing by.

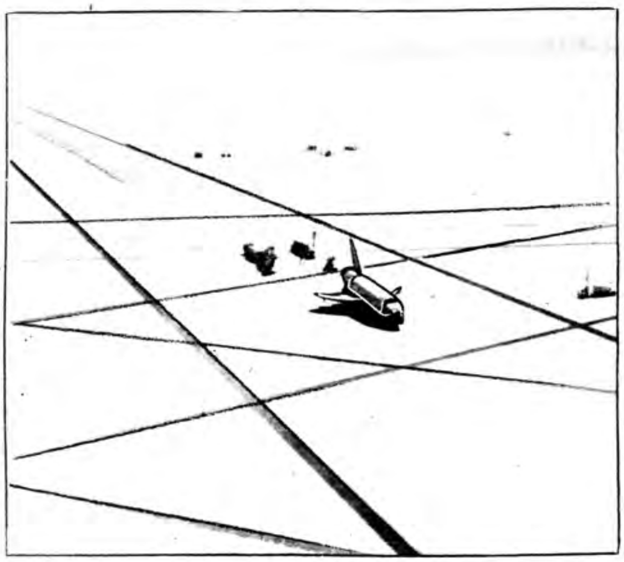
The PA announces "10, 9, 8, 7, 6, 5, 4, go for main engine start." A red flash is visible through the tower as the main engine ignites. Then after a moment, a bigger flash as the solid boosters start and white clouds rise from either side of the pad. The sound of the main engines reaches the viewing site — a steady, even roar. The nose of the External Tank starts to move, rising from the pad. The vehicle is unveiled from behind the changeout room while the press gallery is cheering, yelling "go, go, go." We see the left side of the vehicle as it clears the tower. The main engines exhaust is almost invisible, we see only a few semi-transparent yellow shock diamonds. The Solid Rocket Boosters' exhaust is a brilliant yellow stream and through binoculars it hurts the eyes. The clouds surrounding the pad reflect it, acquiring a yellow cast. The Shuttle climbs much more rapidly than the Saturn 5; it seems to hurl upward as if eager for the adventure. It begins its roll and pitch programme as it heads downrange and the noise is increasing. The underside now faces us. We look up toward the External Tank and the two huge pillars of flame erupting from the boosters. It trails two white plumes and the billows grow and change shape. The sound is a loud crackling roar while the crowd still yells its approval. The PA announces each milestone; first as the Shuttle passes the safe ejection seat speed, then when it can no longer return to the launch site in the event of an abort.

It's real; it's flying! There are tears in the eyes of many spectators. The noise starts to fade. The vehicle is lost in its own plume as it heads downrange and the orange glow starts to disappear. The boosters separate and minutes later the External Tank is jettisoned and the first Orbital manoeuvring engine burn puts *Columbia* into orbit. Each event is greeted with enthusiasm.

The high altitude winds start to twist and scatter the exhaust plume. *Columbia* has reached orbit. Words stop coming — we can only smile and shake hands, the emotions are too strong. The press centre is crowded with more smiling people — NASA, contractors and press. We watch a replay of the launch — the gas venting through the engines, their ignition, then the solid rocket boosters, and the Orbiter taking off. The film shows a tantastic view taken through long range cameras as the solid rocket boosters shut down and seperate, the long cylinders nosing up and peeling back. Applause greets it. At one point, somebody yells "take that, cynics."

April 13

It is quiet at the press site now. The huge number of reporters are gone, like gypsies they have folded their tents and slipped away in the night. A flock of seagulls has reclaimed the parking lot. A few people are in the press centre watching a TV transmission from *Columbia*, the Vice-President talking with the crew wishing them luck. The crew is floating in the spacious mid-deck area, Young in the foreground, Crippen behind. Young starts doing slow aerobatics, headstands and slow rolls.



The first ground vehicles reach *Columbia* after the landing and suited men began to test the area for toxic or explosive fumes.

A representative of *Time* was in the press facility. They had set up extensive remote cameras near the pad and a guard telephoned them after launch to ask if *they* had set up the cameras. When they said yes the guard told them "well, we have the pieces for you."

On our flight back to California, we noticed several people going to Edwards AFB. After landing at Los Angeles international airport we head across the mountains that surround Los Angeles into the Mojave desert to Edwards. Turning onto Rosamond Boulevard, we pass the checkpoint and then, after showing our identification at the Edwards gate, we are allowed onto the base proper. We arrived at the Dryden Flight Research Center in the early morning hours.

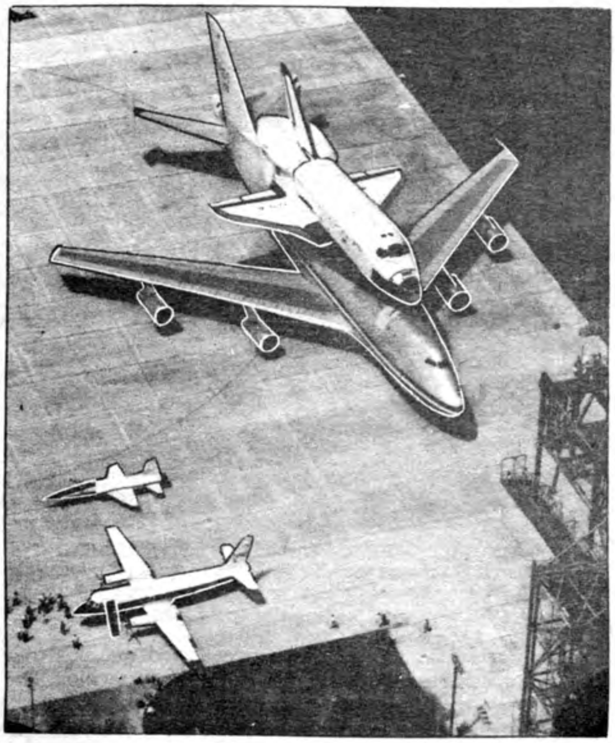
The parking lot is full of cars and in the area near the cafeteria there is a solid mass of network trucks and relay equipment. We get directions to press site A. As the Moon sets, we struggle to get a few hours of sleep before the next day's events. Somewhere above us a vehicle about the same size as the Boeing 727 we flew to California in prepares to make its return to Earth.

April 14

The day of the landing dawns cold, only slowly does the desert Sun drive away the chill. The VIP's start to arrive in buses. A podium for officials and the astronauts sits at one end of the press line. A PA system carries the air-to-ground communications.

The landing site is on the lake bed, its surface dried, cracked mud. When scuffed by feet or tyres, it become a fine powder, and looking across the lake bed, one sees an absoloutly flat, tan expanse. It appears more alien than any surface yet found in the exploration of the Solar System.

At 8.30 am, the PA announces that there is a six mile long traffic jam waiting to get onto the base with crowd estimates running at a quarter of a million. Thus, for a short time, Edwards AFB becomes a significant population centre. A lady is handing out blank commemorative covers to be stamped and addressed at the Edwards Post Office. While waiting, I met some Rockwell employees who had worked on the Shuttle thermal protective system and they explained that the few tiles that fell off had not been densified. If they had, they would not have separated. The area is considered to be non-critical and they do not expect any problems. The strain isolation pad (the felt pad which underlies the tiles) can withstand a certain



amount of heat and the area will be shielded during re-entry.

Special care, they explained, was lavished on the black tiles. These densified tiles are up to four times stronger than untreated ones. To remove one of these, either the SIP pad must be carefully and slowly cut away or the tile must be destroyed. Physically pulling the tiles could actually distort the vehicle structure in certain areas before the tile would let go.

Above, the Shuttle training aircraft makes a steep approach over the press area, then zooms off. Governor Brown appears again, surrounded by a huge crowd of reporters. The PA announces that the Shuttle is beginning to manoeuvre into retro-fire position. When contact resumes at the next ground station word is received that retro-fire was successful. They would land in about 45 minutes. Aircraft continue to fly by — four T-38 chase planes, then four rescue helicopters. The time of atmospheric entry approaches. The burn and entry trajectory are normal, the blackout starts. Young and Crippen are cut off from contact — they are absolutely alone.

It is a long, long wait for contact. A NASA car patrols back and forth to keep the people behind the white chalk line. The crowd is silent.

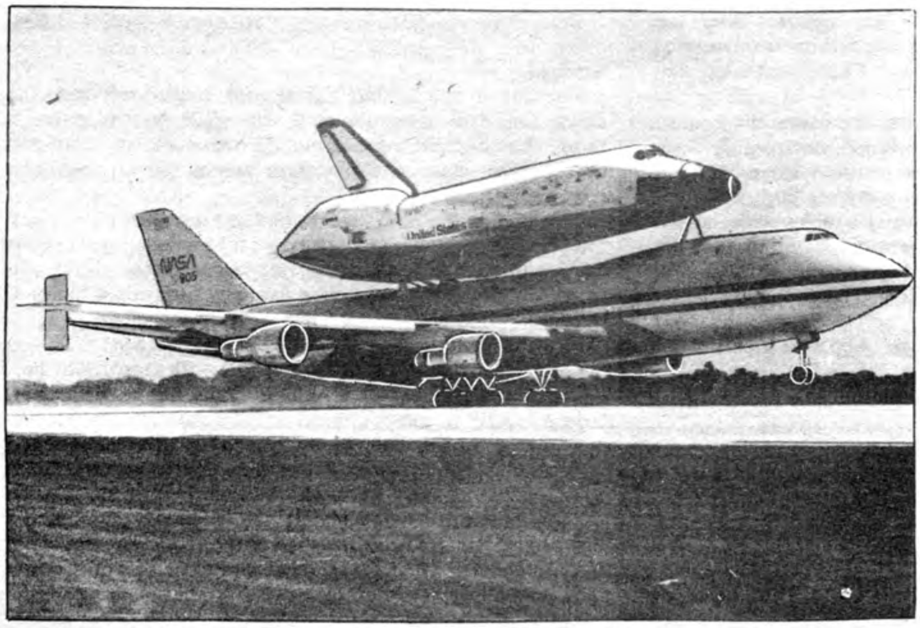
The Sun is hot now, beating down on the thin line of photographers and press stretched across this unearthly landscape. The PA announces a power failure of a radar unit at Vandenberg AFB. It is highly doubtful that any spacecraft recovery has ever had such a large audience on hand since before it was always a private affair involving only the recovery fleet. The PA announces that the C band radar has contact and a cheer goes up as voice contact resumes. The *Columbia* has withstood the fires of re-entry. It is now travelling at something over Mach 10, dropping in speed and altitude. The range decreases as it approaches the landing and Young takes over manual control. The trajectory is perfect. The silent crowd scans the sky looking for a tiny white dot as *Columbia* continues its approach. Its arrival over the Mojave is announced by twin sonic booms.

The PA give speed and altitude readings. Then, through binoculars, a tiny white dot appears, almost lost in the vast blue sky. The Shuttle grows steadily larger as the moments pass. The features start to resolve and a chase plane joins it. The pair, so different in size and performance, turns toward the runway marked on the lake bed. No sound reaches the press site. The Shuttle glides smoothly as if on rails and the ground appears at the bottom of the binocular field. The Shuttle flares and the landing gear comes down. The chase plane starts to read off the altitude remaining "50, 40, . . . 3, 2, 1, touchdown." The crowd starts to cheer, the main landing gear wheels kick up a cloud of dust and the nose comes down and then touches. *Columbia* begins to slow and finally stops. The support trucks rush toward it as *Columbia* sits out on the seemingly infinite lake bed.

The *Columbia* is home.

Acknowledgements

A very special thanks must be given to those who helped along the way: Kenneth Gatland, Peter Campbell, Mr. and Mrs. Charles Campbell, Mr. and Mrs. Phil Henderson and the Reuban H. Fleet Space Theater.



Left: Columbia and the 747 Shuttle Carrier Aircraft land at the Kennedy Space Center after a 1087 mi flight from Tinker AFB in Oklahoma, following an over-night stop. *Top left:* awaiting the demating procedure before *Columbia* can be prepared for STS-2, scheduled for 30 September.

BRITISH SPACELAB 1 EXPERIMENT

By Keith Wilson

The first Spacelab mission currently scheduled for mid-1983 has had 37 experiments recently approved by ESA/NASA for the flight. This first joint European/United States manned spaceflight will last for a week and carry six astronauts, including one European payload specialist, into orbit.

One of the experiments selected has been designed by University of Stirling psychologist Dr. Helen Ross. The experiment, Mass-discrimination during weightlessness, is aimed at investigating the rate of man's adaptation to zero gravity and the rate of postflight recovery. Dr. Ross's experiment will involve the six astronauts in judging the mass of objects in zero gravity and will consist of preflight, inflight and postflight tests.

Although no similar experiments have been performed in space, evidence from Earth-based experiments where weightless conditions have been simulated appear to indicate that objects are estimated to be lighter than in normal conditions. These Earth-based experiments, however, do not provide the conditions of prolonged exposure to zero gravity which are needed for the investigation of Man's capabilities in a weightless environment. Only a space mission can provide these unique conditions. Based on the experiences of previous manned space crews Dr. Ross predicts that mass-discrimination will deteriorate on encountering zero gravity and also on return to one g. It is hoped to learn exactly how long adaptation will take and whether performance will be at the same level as on Earth, or at a poorer or better level.

The apparatus to be used in this experiment consists of a box containing twenty four weighted balls and a set of record cards. The box measuring 30×20×14cm in the closed position unfolds to a maximum of 67×30×7cm. The box, kept closed by two latches, unfolds into two trays and a desk. Brackets on the outside of the trays are used for securing the experiment by elastic cords to the Spacelab workbench. The desk holds a set of forty record cards held in place by a spring clamp which are used by the astronauts to record results during the experiment. Completed cards are deposited into a false bottom under the left tray through a slot. Each tray contains twelve balls each 3 cm in width. The balls, which vary in weight from 50 to 64g, arecomposed of three parts. The outer dark grey shell is epoxy resin, the middle section is lead, with the core filling also of epoxy resin. All of the balls are marked with an identification letter (A-X) and are secured to the box by elastic retaining straps.

The astronauts involved in the Spacelab 1 mission will conduct preflight tests on two occasions during the week prior to the flight using ground-based apparatus. During the flight itself the astronauts will spend a minimum of two hours and

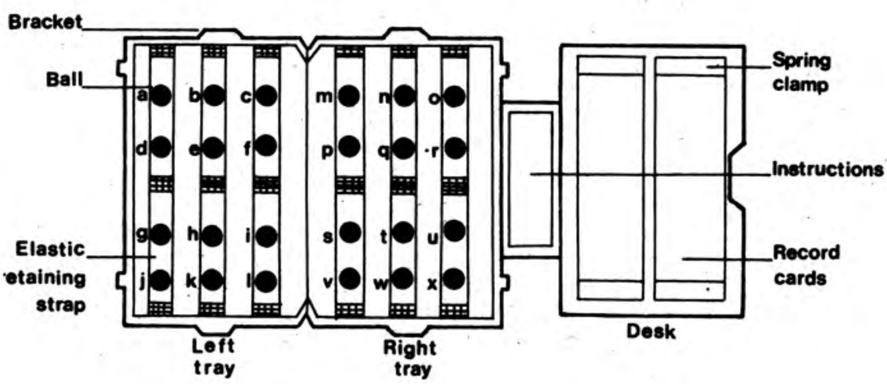
twenty minutes conducting inflight tests with the Mass-discrimination experiment. The backup crew will conduct similar tests on the ground. Each test, the first taking place soon after entering orbit, will last approximately thirty minutes. The astronaut unstows the experiment box from its location in the Spacelab module and after securing it to the workbench he records his name, the date and time on the top record card. After reading the first pair of letters listed on the record card the astronaut picks up the first ball and, holding it loosely, shakes his hand freely. The ball is then replaced and the same procedure is completed for the second ball. The astronaut then has to decide which of the two balls had the greater mass. The result is recorded on the record card and also by voice-link. He repeats this procedure for all 72 letter-pairs listed on the record card and records the time on completion of the test. The record card is deposited through the storage slot under the left tray and the apparatus is then stowed.

As soon as possible after the landing postflight tests will take place and by comparing results taken before, during and after the Spacelab 1 flight Dr. Ross hopes to learn just how reliable the skill of mass-discrimination is in varying conditions.

Acknowledgment
The writer would like to thank Dr. Helen Ross of the University of Stirling for her help in providing material for this report.

Mass-discrimination during weightlessness.

Experiment apparatus (open position).



Right: the mass-discrimination experiment due to be flown aboard Spacelab 1 in 1983. *Top right:* ex-Skylab astronaut Owen Garriott runs through the experiment during a training exercise in Cologne, W. Germany.

NEWS FROM THE CAPE

By Gordon L. Harris

INTO THE SOLAR SYSTEM — OR NOT

US planetary exploration has been slowed by Shuttle demands upon NASA funding and retrenchments ordered by the Reagan administration.

Slicing $640 million from the 1982 budget proposed by former President Carter, Reagan's trimming hit hard upon agency planetary projects, which were reduced by 25 percent. The only major undertaking in this decade will be Galileo, a two-part spacecraft aimed at Jupiter and costing £645 million.

Some 20 months later when approaching Jupiter, Galileo will dispatch an instrumented probe towards the dense atmosphere until destroyed by high temperatures and pressures. The parent ship will orbit the planet and provide more information concerning its satellites.

Andrew Stofan, deputy associate administrator for space science, told the 28th Annual Space Congress held in Cocoa Beach that the US will be left behind by other powers unless the administration changes its policy. The Soviet Union and Europe's space agency plan launches for the Comet Halley opportunity which NASA is unable to exploit. There were hints of a possible Soviet expedition to Mars while NASA's hope of a manned journey to the Red Planet apparently died with Wernher von Braun.

But the Space Congress, sponsored by Canaveral Technical Societies, seemed to echo Reagan's choice by devoting far more time to the reusable Shuttle two weeks after *Columbia's* triumphant debut. NASA and the Air Force gave the new transportation system top billing. Its impact upon more conventional rocket systems was clearly uppermost in the minds of their manufacturers. Papers dealing with Scout, Delta, Centaur and Titan promised greater weight lifting capacity as alternatives for the new vehicle.

Meanwhile, Japan is doing very well with its N-1 vehicle (130 kg to geostationary orbit) and successfully tested its N-II in February. The new version can place 350 kg in geostationary orbit.

ON THE SHUTTLE FRONT

NASA disclosed the Shuttle programme costs during the STS-1 launch period to be: for design, development, test and engineering, $9,912 million; for production of two more Orbiters (total of four in the fleet), $5,603 million.

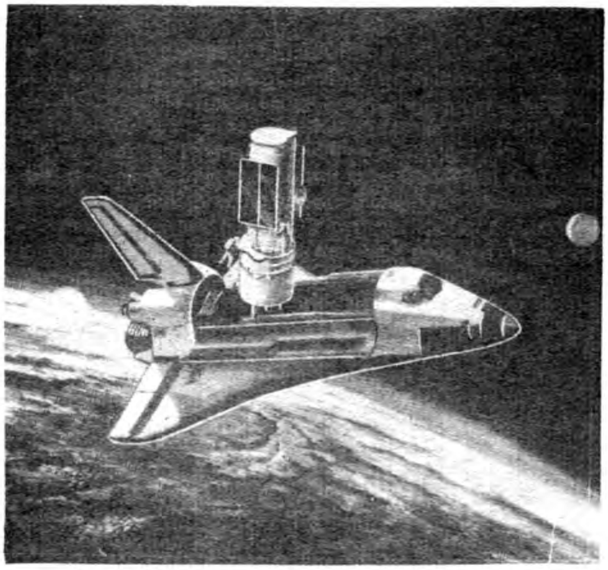
"The original cost estimate in March 1972 for Shuttle development was $5,150 million in 1971 dollars," the agency said. "The current estimate equates to $6,654 million in 1971 dollars."

Each Orbiter costs about $1000 million in 1982 dollars, or £490 million in 1971 currency.

As to the division of effort among contractors, NASA listed them as follows:

Rockwell (Orbiter)	$3,560,000,000
Rocketdyne (main engines)	1,546,000,000
Martin Marietta (External Tank)	529,000,000
Thiokol (Solid Rocket Boosters)	206,000,000
USBI (rocket assembly and recovery)	89,000,000
McDonnell Douglas (OMS/RCS pods)	85,000,000
McDonnell Douglas (support)	52,000,000
Grumman (wings)	45,000,000

The tape from a flight instrumentation recorder recovered from one of the Solid Rocket Boosters used in STS-1 on 12 April recorded more than 600 different vehicle performance parameters.



The Space Telescope will be one of the Shuttle's most important scientific payloads this decade. NASA is hoping to attach a boost unit to the Shuttle so that it can lift even heavier objects into orbit.

While basking in acclaim following *Columbia's* first mission, NASA has more development work ahead before the reusable vehicle can live up to well advertised claims.

The space agency promised a capability of 65,000 lb of cargo launched to the east from the Cape and 32,000 lb in polar orbit when launched from Vandenberg Air Force Base, California where most military missions will begin.

"It is important to the future that performance augmentation be developed and made available to meet payload requirements which exploit Shuttle's capabilities," William Goldsby, systems engineering chief in the Space Transportation System office, told the 18th Space Congress recently (29-30 April, 1 May).

Goldsby discussed options under consideration which include uprating Shuttle's main engines to 115 percent of rated power level, lighter cases for solid booster rockets (filament wound), and a liquid boost module derived from Titan. All three will be studied in detail for selection and initation of development in Fiscal year 1983 to support requirement dates.

Goldsby outlined current steps being taken to increase payload capability, such as reducing crew size and mission duration from 4 men, 7 days to 2 men, 1 day; reducing inert weight in Orbiters and the External Tank, and improving solid rocket performance. By April 1983 NASA expects to have the 65,000 lb capability with *Columbia*, and then Challenger and Discovery in 1983 and Atlantis in 1984.

These measures, however, will not yield the performance at the Western Test Range - to deliver 32,000 lb to a 150 nautical mile circular orbit at an inclination of 98 degrees, and then to retrieve a 25,000 lb spacecraft from orbit in a single mission.

NASA must take other steps to overcome the 8,000 lb deficit.

The liquid boost module (LBM) has been studied in detail and found to be practicable. This would employ a Titan first stage engine with shortened Titan tanks mounted under the 154 ft fuel tank as a strap-on system.

"Space available under the tank is more than adequate to install an LBM system capable of boosting payloads on the order of 14,000 lb for Western Test Range missions," Goldsby observed.

For the next year NASA will investigate the feasibility of uprating the main engines and developing filament wound solid booster cases.

NEW NASA ADMINISTRATOR

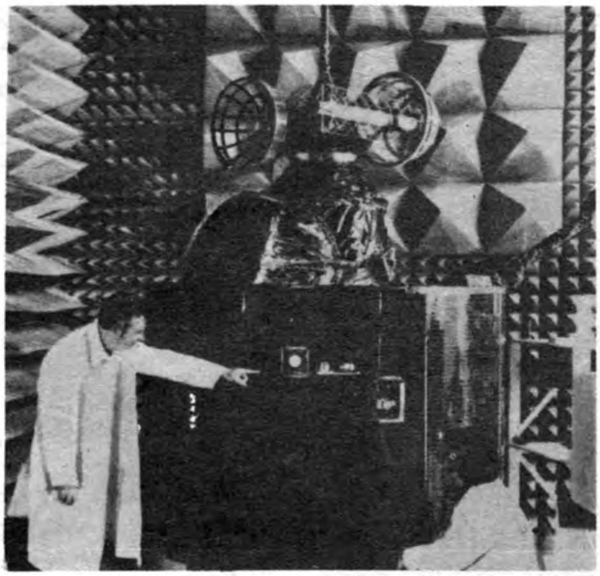
President Reagan has chosen James Montgomery Beggs to become NASA Admministrator, succeeding Dr. Robert Frosch who resigned when Jimmy Carter left the White House. Beggs will leave his position as executive vice president for Aerospace of General Dynamics.

No stranger to NASA, Beggs served as associate administrator in 1968-69 of the Office of Advanced Research and Technology. His firm supplied Atlas boosters to the space agency, beginning with Project Mercury in 1961-62. Atlas is currently used with the liquid hydrogen upper stage, Centaur, for geosynchronous orbit missions, boosting about two tons over the equator to 22,300 miles altitude. NASA expects to phase out Atlas and Delta boosters in 1985, depending upon Shuttles and high performance upper stages to take over civil and military space missions.

Hans Mark will become deputy administrator. Once director of NASA's Flight Research Center, Mark has served as Air Force secretary since 1979.

USE OF THE CAPE

A new order is in store for Kennedy Space Center according to its director, Richard Smith. In the next three years, or about the time that Shuttles become fully operational on West and East coasts, the launch base will have three major contractors: one for Shuttle launch processing, another for cargo processing, and a third for general support. Additional responsibilities will be assigned to contractors, permitting a reduction in civil service employment unless new roles are found. The transfer of operating functions to industry is in line with NASA's philosophy which requires concentration on research and development. KSC engineers expect by 1984 to have cut Shuttle processing time between flights to 400 hours or about half as long as *Columbia* waited for its first launch. "We're moving towards an airline type operation," observed Don Phillips, test and Shuttle recovery chief.



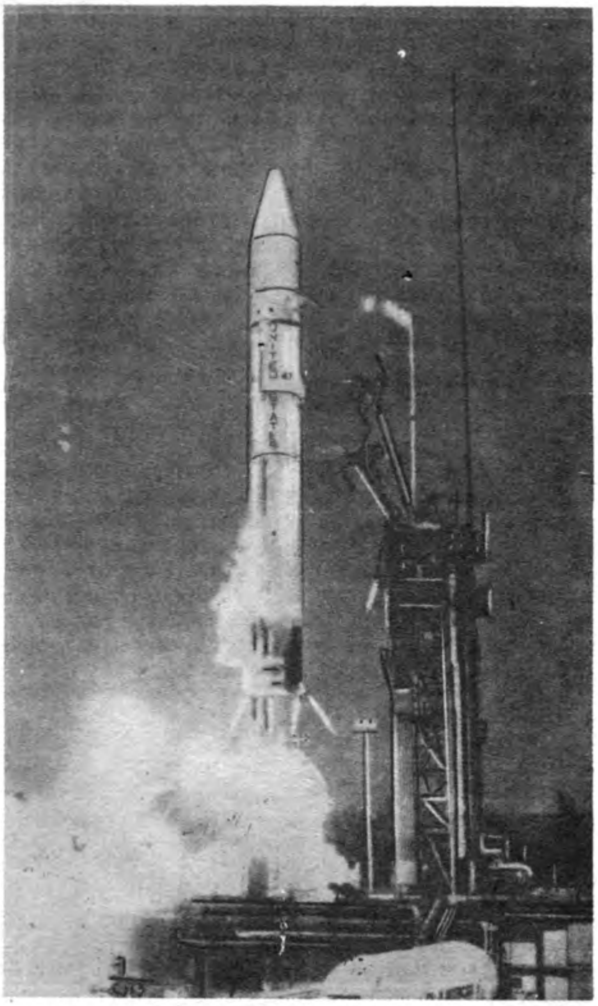
The GOES 5 weather satelite was scheduled to be launched by Delta rocket in May (See Space Report). Besides providing atmospheric and sea temperature information, its frequent pictures from geostationary orbit will give warnings of dangerous weather conditions.

ATLAS AND DELTA MODIFICATIONS

Commercial users are pressuring NASA for more expendable boost vehicles. Several innovations are in progress to upgrade th performance of Delta (one ton in geosynchronous orbit) and Atlas (two tons for similar missions).

McDonnell Douglas, Delta manufacturer is developing a payload assist module (PAM) which commercial users will buy to handle the propulsion requirement from low Earth orbit to geosynchronous altitude.

General Dynamics is enlarging Atlas tanks to increase its weight lifting capability. Combined with Centaur, Atlas will boost a new family of Intelsat communications satellites this year and next. Meanwhile, Delta will handle lighter payloads.



NASA hopes to be able to phase out Atlas, Delta and Scout by the end of 1985. Atlas, *above*, saw its first launch in 1957.

THE MARTIAN ROVERS

By Curtis Peebles

Introduction

In the early hours of 20 July 1976, mankind received its first photos from the surface of Mars. In the months and years that followed, more images would come from the cold lonely Martian plains. Yet for all the accomplishments of the two Viking landers, they had shown us only a small area of Mars. Dividing the red dusty surface and the orange sky was the distant unknown horizon, always beckoning onward. And for all the stationary landers could tell us just beyond that horizon awaited the fabled, jewelled towers of some long dead Martian civilization.

The Langley Rovers

Studies into ways of seeing beyond the Martian horizon date to 1972. Five concepts were developed at NASA's Langley Research Center, each one with increasing range and sophistication. The most elementary was the cable-controlled rover. It had a range of 164 ft (50 m) and carried a sampler scoop and an X-ray fluorescence spectrometer. The most complex was the autonomous rover having a range of 62 miles (100 km), on-board sampling equipment and direct communications with Earth. In between was the small rover, battery powered, 328 ft (100 m) range, camera and scoop. The medium rover had a 0.62 mile (1 km) range, stereo camera, drill, scoop, and was nuclear powered. And lastly, the advanced rover — 6.2 mile (10 km) range, nuclear and battery powered, scoop, drill, stereo camera, communications via the orbiter rather than through the lander [1]

The autonomous rover was further refined during the next two years. In this later version, the rover would be carried aboard a Viking lander, necessitating the removal of one camera. The vehicle would have a range of 28 miles (45 km) and weigh 238 lb (108.2 kg). Of this, 89 lb (40.5 kg) would be scientific equipment. It would carry a camera, a RTG nuclear generator, a scoop, an X-ray diffractometer and an Alpha backscatter spectrometer. Its mission was photo and geochemical survey. It would look for sub-surface water using on-board equipment and the basic Viking science package. It would, also, perform rock sampling, locating and cataloging interesting areas such as rock niches [2].

Post-Viking Rovers

The Jet Propulsion Laboratory, shortly after the Viking landings, announced a study of advanced Lunar and Planetary explorations. It was called the Purple Pigeons — bright birds of the future. For Mars, they planned two orbiter/landers. Each lander would carry two rovers. Once on the surface, they would be controlled *via* relay satellite in synchronous orbit. Each rover would weigh 441 to 551 lb (200 to 250 kg) and carry a TV camera, manipulator arm for picking up samples, as well as geological, chemical and meteorological equipment, X-ray and gamma-ray spectroscopes and multi-spectra photo systems. It would also look for signs of life.

To perform soil studies, the rovers would each carry an optical microscope and a seismic 'thumper'. The two rovers would work together; for example: one rover would use its 'thumper' while the other would listen for the returning echoes. The science packages would be complementary. If one should run into difficulties, the other could assist.

The rovers would be 3.28 ft (1 m) wide and 9.84 ft (3 m) long and ride on 6 wire mesh wheels like those used on the Apollo lunar rovers. The rovers could cover 621 to 932 miles (1,000 to 1,500 km) in one Martian year — moving at 1.86 to 2.5 miles (3 to 4 km) a day. Using lights, they could work during the night and in craters. Later studies, however, indicated that it would be preferable to have the two rovers working separately surveying different areas [3, 4]. Another proposal was to convert the Viking lander itself into a roving mobile laboratory. The hardware would be spare flight qualified vehicles. To provide mobility, each footpad would be replaced by an elastic loop similar to caterpillar tracks but lighter and less complicated. It would provide uniform low ground pressure giving a smooth ride over rocks and soft soil. The tracks would swivel for course changes. The rover would move 328 ft (100 m) at a time, two bumpers extending out from the side. Any contact with an obstacle would cut off power. Its range would be about 90 miles (150 km). Tests indicated that it could climb 30° to 40° slopes. Martin-Marietta had been studying a mobile Viking since 1974.

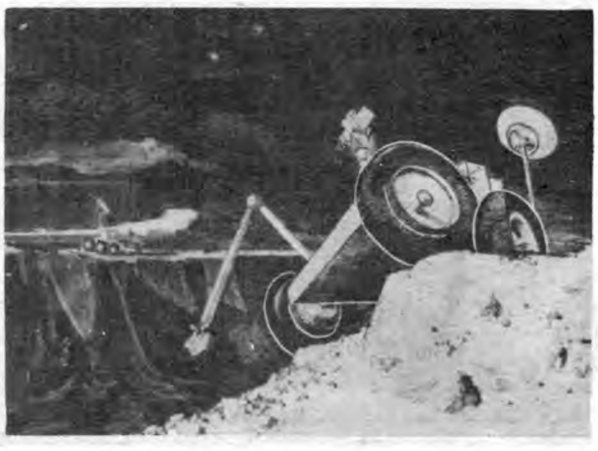
The Viking 3 would be equipped with a new unified biological instrument. It had 11 test cells for analysing Martian soil. An Alpha-Proton X-ray experiment, similar to that used on Surveyor, would be used to determine elemental composition of the surface and an X-ray diffractometer used for mineral studies. It would, also, carry a crusher/grinder so that a wider variety of surface samples could be analysed. The increased power requirements meant that a more efficient RTG nuclear power source would be required [5, 6].

Mars Ball Probe

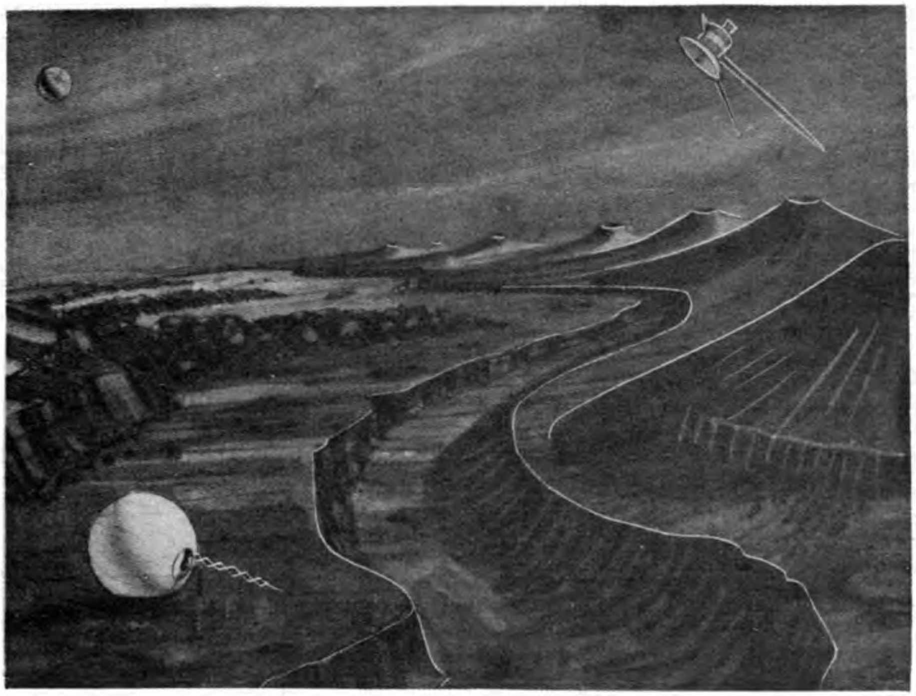
Another unusual post-Viking concept is the Mars Ball probe. This rover is a beach ball-like device; it would roll across the Martian surface using either on-board systems or the Martian winds. It carries science and guidance equipment and can be stopped and started. The concept had been studied by both JPL and the French Space Agency. One wind-blown rover had a 44 to 66 lb (20 to 30 kg) science package and would inflate and deflate on command. This rover does have some problems, mainly in assuring reliability and equipment placement.

By the second anniversary of the Viking landing, it had been agreed that the next US Mars probe would involve some type of rover system. After several years of study, two basic ideas developed — the autonomous rover having a long range to carry out exploration away from the lander and/or a teleoperated mini-rover.

The autonomous rover would be about the size of a large desk. It would use the same kind of elastic loop treads as the Viking 3 proposal. It would travel about 61 miles (100 km) in one Martian year. The science package would weigh between 220 and 352 lb (100 and 160 kg). It would carry stereo cameras and a manipulator arm, and small science packages could be dropped off at selected locations. Power would come from a



The two Purple Pigeon rovers. In this concept the two rovers would work together like the Apollo lunar astronauts.



In this JPL illustration, the Mars Ball surveys a dry river bed. The sampler arm and antenna extend out through an opened port. Data is relayed *via* an orbiter to Earth.

250 watt RTG. Unlike previous concepts, the vehicle would be self-navigating without detailed instructions from Earth. The autonomous rover would survey the terrain, detect any obstacles, remember them and plot a course to avoid them. It would have a proximity sensor, laser ranging instruments, stereo cameras and a computer to evaluate the data. A self-navigation capability would avoid the bottleneck caused by the many minutes delay required to get a signal from Mars to Earth.

The teleoperated mini-rover, on the other hand, would be a very simple vehicle with none of the sophisticated systems of the autonomous rover (one drawing shows a box on two wheels and a tail skid). Equipped with a camera and drill, it would act as an extension of the lander. Its function would be as a sampler and to deploy science packages. It would travel only a few metres a day and probably not leave the viewing area of the lander [7].

A Martian Air Force

An alternative to surface rovers is the astroplane. It has its origins with the minisniffer. This is a model airplane-like remote piloted vehicle. It could reach altitudes of 102,500 ft (31,250 m) for atmospheric and Earth resource studies. It, also, has the distinction of being the highest flying propeller driven aircraft in the world.

Because of its operating altitude, the minisniffer uses a hydrazine-fuelled engine. Since such an engine is so new, it has low reliability. R. Dale Reed, of the Dryden Research Center at Edwards Air Force Base, went to JPL seeking information on a hydrazine gas generator used on an early Mariner. Reed saw Joe Chirivella. During their discussions, Chirivella recognised the possibilities for a Martian aircraft. After doing some calculations, Chirivella went to Victor Clarke, who was working on follow-on Mars missions. His initial reaction was "an airplane on Mars — you've got to be kidding!" But after examining the idea closer, he enthusiastically accepted leadership of the Mars aircraft programme [8].

The aircraft has a wingspan of 68.88 ft (21 m) and is 21 ft (6.4 m) long. The deeply curved wings are only 1.97 m (5 cm) thick. The airframe is made of carbon fibre material and weighs, empty, only 81.41 lb (37 kg). It resembles a high performance sailplane. A 15 h.p. hydrazine airless engine turns a 6.6 ft (2 m) diameter propeller. Maximum speed would be 295 ft/second (90 m/second) dropping to 196.8 ft/second (60 m/second) at fuel exhaustion. The astroplane's range with 88 lb (40 kg) of scientific equipment would be 4,164 miles (6,700 km) and it would stay aloft for 25.5 hours ranging in altitude from

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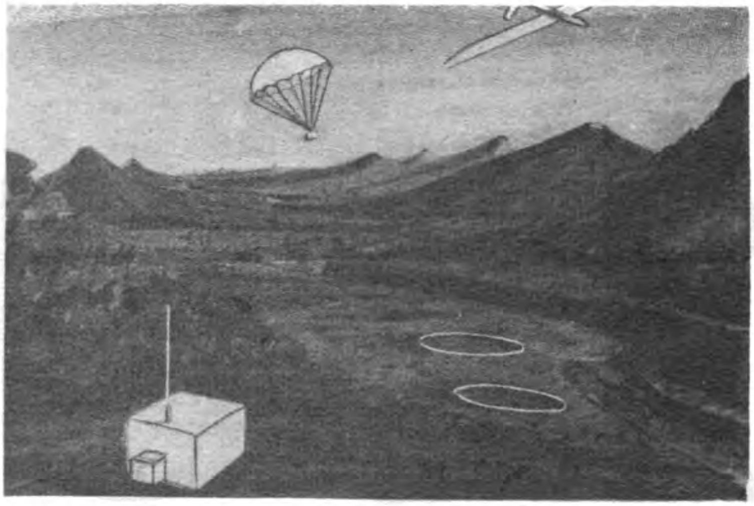
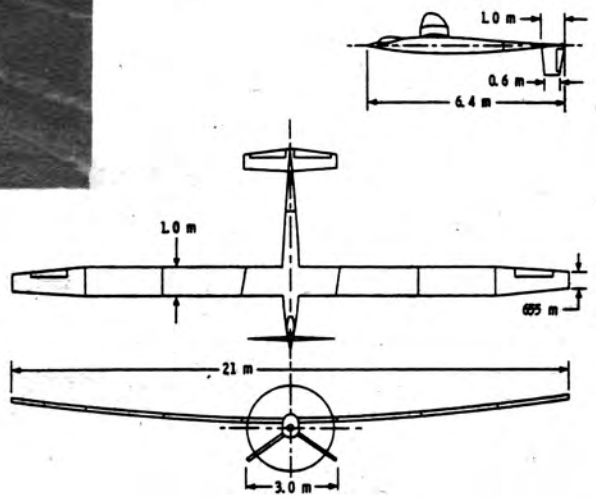
The Trojan Relay communication system, first proposed by James Strong in *Wireless World*, March 1967, would be ideally suited for the uninterrupted guidance of a Martian surface rover. Two-way communication could be set up by stationing a pair of relay satellites at the Trojan Points of a Mars orbit, 60° ahead and behind Mars itself. From there, with their primary aerials 'illuminating' both Martian hemispheres, and with secondary aerials pointed Earthwards, continuous contact with a surface rover can be maintained 24 hours a day.

If both video and communication signals are coupled to a telefactor system, a television-guided mobile probe can be steered from Earth by a human operator seated at a set of duplicate controls. As he turns his head the TV camera mounted on the probe, millions of miles away, duly follows suit. If he leans forward, its lens zooms. If he stretches out an arm to touch a switch, or pulls on a dummy wheel, he actuates corresponding switches or steers the roving probe. He can even change a fuse, or carry out repairs to the rover, if he has an extra arm.

Telefactor systems need little development. Already, motor-driven mechanical arms and clawed fingers gently handle deadly radioactive substances by remote control. Driving rovers on another world should be easy. The only problem might be the delay before a signal from Earth can reach the rover in time to stop it falling into a crater. Delays of 9-12 minutes must be allowed for even when Mars is closest to Earth, and this becomes progressively longer as the two worlds separate. To avoid obstacles there will need to be sensing devices probing ahead of the rover, backed by a long-range camera scanning sufficiently far ahead to warn of impending difficulties.

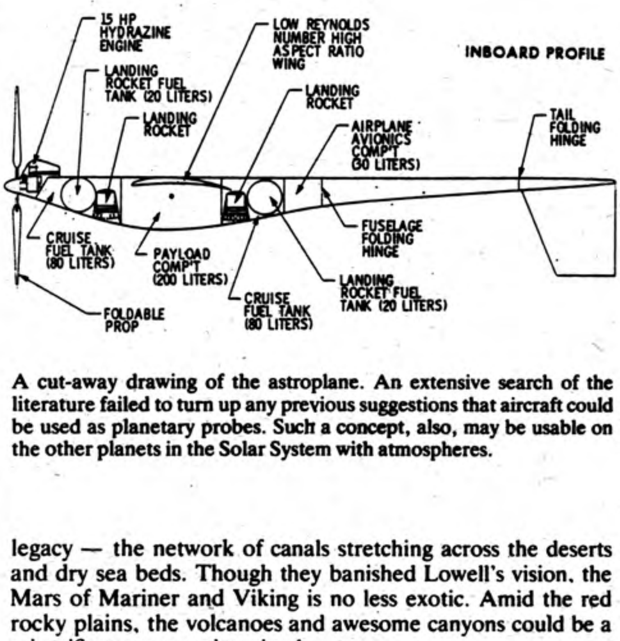


Another possiblity for the astroplane would be to drop scientific packages and navigation aids. Because of its range, this network could extend over the entire planet.



1,640 ft to 9.32 miles (500 m to 15 km).

The payload compartment would be 3.28×1.64×1.48 ft (1×0.5×0.45 m). A plastic bubble protruding from the underside would give a full hemispheric view. Instruments could, also, be mounted under the wings. The astroplane might even accomplish vertical landings and take-offs using two Viking landing rockets. This would, however, cut severely into the range. There would be a 2 ft (0.63 m) clearance between the underside and the ground.



A cut-away drawing of the astroplane. An extensive search of the literature failed to turn up any previous suggestions that aircraft could be used as planetary probes. Such a concept, also, may be usable on the other planets in the Solar System with atmospheres.

Mission Profile

Three orbiter/astroplane carriers would be launched toward Mars. Each would carry four astroplanes to make a total of 12. Each astroplane is individually enclosed in a Viking aeroshell, the wings folding into seven 9.84 ft (3 m) long segments. The propeller, tail and fuselage are, also, folded. After atmospheric entry, the astroplane separates from the aeroshell and opens a parachute. The astroplane unfolds, starts its engine and takes to flight, with navigation systems using a strapdown inertial system, doppler radar, radar altimeter and terrain avoidance radar. The inertial and doppler systems generate steering signals. Navigation fixes use turnaround ranging measurements to the orbiter.

Communications with the orbiter is through a steerable array mounted on a wing panel. The astroplane would take high resolution multi-spectral photos, make magnetic, gravity and geochemical surveys, search for sub-surface water, geothermal fields and active volcanoes. It can, also, perform atmospheric soundings and analyses as well as deploying soft landing mineral or biological experiments, mini-rovers, navigation aids and a network of meteorological and seismic stations. The astroplane could, also, be used to make site surveys for Mars sample return missions and, if equipped with landing rockets, gather samples from widely separated areas and bring them to a central location for a pick-up [9].

Conclusions

At present, both the US and Russian exploration of Mars is in eclipse — the US because of lack of will; the Russians because of poor results. However, in the USSR there are signs that this situation may not last much longer and man's mechanical emissaries will return to Mars. This planet has always held a particular fascination. For thousands of years, it has been like a mirror in the sky reflecting man's hopes and fears — the most Earth-like of planets, perhaps with some form of life. The possibility was vividly described by the astronomer Percival Lowell, with his images of a dying civilisation and its legacy — the network of canals stretching across the deserts and dry sea beds. Though they banished Lowell's vision, the Mars of Mariner and Viking is no less exotic. Amid the red rocky plains, the volcanoes and awesome canyons could be a scientific treasure unimagined.

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COMSAT NEWS

A NEW TELSTAR

The name Telstar brings back memories of the early 1960's when communication satellites were very much an unknown quantity, *writes Andrew Wilson*. Telstar 1, launched on 10 July 1962 by Delta, was not the first comsat but it did provide the first active-repeater satellite TV link across the Atlantic. Telstar 2 came the following year.

Now, AT & T, the owners of the original Telstar, are waiting for Telstar 3 to be built by the Hughes Space and Communications Group. In fact, there will be three put into geostationary orbit - in June 1983, May 1984 and early-to-mid 1985. These are part of the fleet of fifteen Hughes HS 376 comsats under order or already in space.

Hughes have produced a basic comsat which can be modified to suit a customer's need and launched by Shuttle, Delta (the 3900 series) or Ariane. Its most striking feature is the 'sleeve' arrangement of solar cells. Costs for using the Shuttle depend partly on the length of cargo bay occupied and by having a cylindrical main body covered by cells and a cylindrical outer shell with more cells for deployment once in orbit, the satellite can be carried upright to save space.

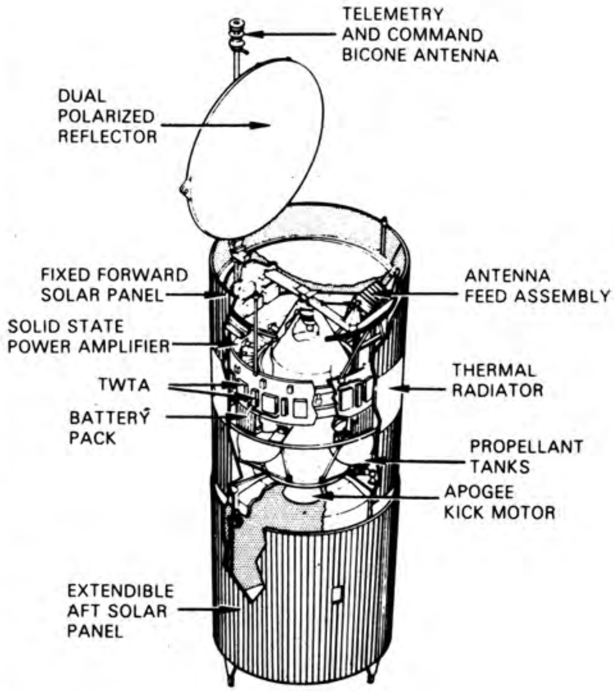
In its stowed position, the 216 cm (85 in.) diameter satellite is 274 cm (108 in.) tall but on full deployment it stretches to 643 cm (253 in.) - about two stories high. Like previous Hughes comsats it is spin stabilised (3-axis stabilisation is more difficult and costly to achieve) so that the antenna and equipment shelf have to be despun to keep pointing at their ground targets.

The antenna uses a reflector looking rather like a clam shell on top of the body. In fact, it has a double reflecting surface sensitive to either vertically or horizontally polarised beams in order to increase the communications capacity. Telstar 3, for example, will be able to cope with 21,600 simultaneous telephone calls - almost twice the capacity of Intelsat V.

After the Thiokol Star 30 apogee motor has fired to establish geostationary orbit, the HS 376 typically weighs about 555 kg (1222 lb) at the beginning of its 7-10 years useful life.

Apart from the three Telstar 3 satellites, the other 12 are:

Anik C:	three being built for launches beginining this year. With double Anik A's capacity, the 12/14 GHz frequencies will cover the more densley populated areas of southern Canada.
Anik D:	two using the 4/6 GHz frequencies will cover all of Canada.
Palapa B:	similar to Anik D: two intended for 1983 launches for Indonesia.
SBS:	three US domestic comsats were ordered in December 1977; the first is already in operation.
Westar IV:	for launch in early 1982; a second may be flown. Another US domestic comsat.



The Hughes HS 376 comsat.

NEW SPACE BATTERIES

Batteries used in spacecraft have always posed problems for designers because they have tended to be heavy and relatively short-lived. Now, Intelsat, through its interest in providing power for its communications satellites, have produced a nickel-hydrogen battery which should last longer and weigh less.

Comsats usually draw their power from solar cells converting sunlight into energy but when their orbits take them into the Earth's shadow they have to rely on their batteries. Until now, nickel-cadmium batteries have been used but they degrade after about four years in space and generally have a useful lifetime of only seven years, a major limiting factor in designing a comsat.

Inteslat belive that the new sets of batteries (costing well over $100,000 for each satellite!) will have orbital lifetimes of at least 10 years, and they plan to include them on the fifth, sixth and seventh Intelsat V comsats due for launch next year.

UK—USA COMSAT SHARING

Following an earlier signing of a Memorandum of Understanding, British Aerospace Dynamics Group and Comsat General Corporation are working on plans to form a joint venture which will lease military satellite communications services to user organisations. A proposal has been submitted to the Ministry of Defence for leasing such a service to meet UK military requirements.

Comsat General is currently under contract to the Royal Navy to supply a defence communications service *via* the Marisat satellite system. Established in 1976, Marisat provides a worldwide communications service to the US Navy, as well as the commercial market and offshore industries and was the first satellite system to be established to provide leased defence communication services.

The leasing concept, on which Comsat General has based the operation of its satellite systems, provides direct financial benefits by relieving the UK Government of the need to invest large amounts of capital at the beginning of the programme. Instead, payment is deferred until commencement of the service and proportional to the service provided.

Comsat General and British Aerospace have a long history of involvement in the field of satellite communications. The experience of the CGC team extends over the past 15 years during which time it successfully established satellite communications systems with a total of 32 satellites. In the course of these activities, Comsat General functioned as system designer, operator, and manager, and has acted, on behalf of other organisations, to monitor the design, construction and launch of a wide variety of satellites. British

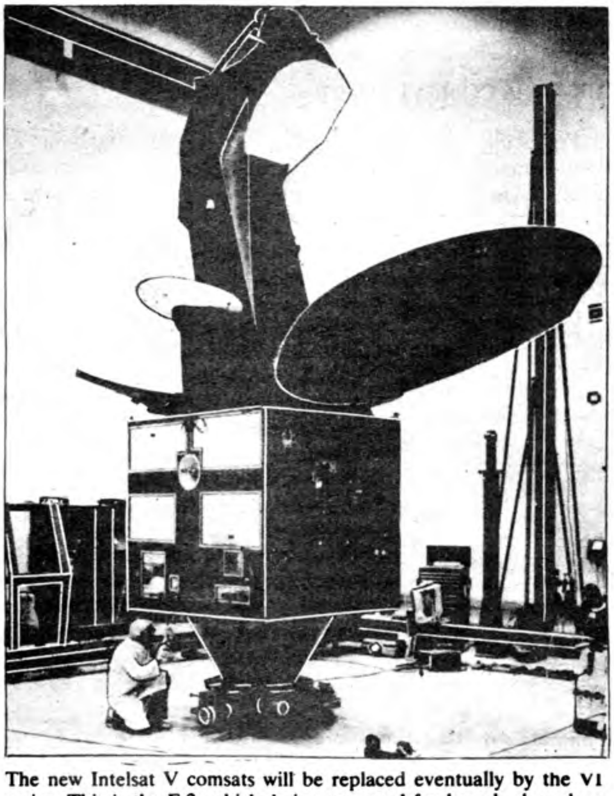
Aerospace has contributed to the successful operation of Intelsat programmes, which has established the Company to achieve the distinction of being the only non-US contractor involved in Comsat General's 'Comstar' programme. 'Comstar', leased to American Telephone and Telegraph Company and General Telephone and Electronics, provides long distance telephone communications within the United States and to offshore points.

NEW COMSATS

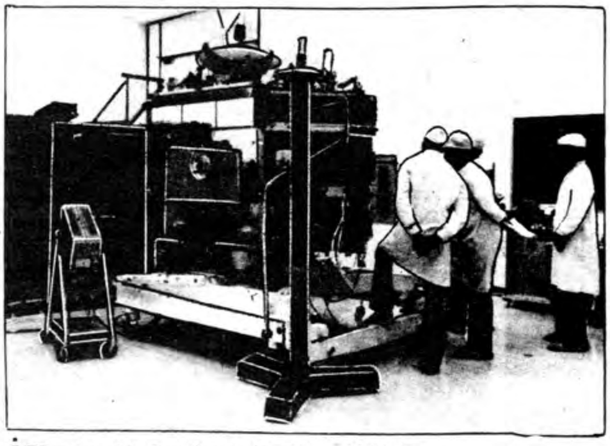
INTELSAT, presently launching its Intelsat V series of comsats, have asked for proposals for the next generation of vehicles. These new comsats should be able to handle 40,000 telephone calls and two TV transmissions simultaneously by reusing frequencies in the 6/4 GHz and 14/11 GHz bands. At present, the IV, IVA and V series are relaying traffic from their geostationary orbits high above the Atlantic, Pacific and Indian Oceans, but as they begin to drop out of service in the middle of this decade and communications demands continue to increase the VI series will be needed. The first launch is expected sometime in 1986 and the resulting capacity should be sufficient to satisfy demands until around 1992.

INTELSAT, the 105 member-country organisation, runs the satellite system which handles about two-thirds of the world's trans-oceanic communications links. It formally came into being in April 1964 and a year later it had the *Early Bird* satellite (later known as Intelsat I) in orbit to begin the first commercial comsat service on 28 June. Even though it could cope with only 240 telephone calls or one TV transmission, it increased the trans-Atlantic capacity by 50%.

INTELSAT knew that *Early Bird* was only a small beginning and that it would have to provide larger satellites to cope with



The new Intelsat V comsats will be replaced eventually by the VI series. This is the F-2 vehicle being prepared for launch aboard an Atlas-Centaur last December. Another four should have joined it in geostationary orbit by the end of this year.



OTS entered its fourth year in orbit on 11 May.

the demand. The first Intelsat II (briefly known as Bluebird) failed to reach orbit in October 1966 but the second was successful the following January. Two were eventually placed over the Pacific and one over the Atlantic.

The first Intelsat III, with a 1200 circuit capacity, was lost in a launch failure in September 1968 but by the end of the decade trans-oceanic demands were being met by a combination of Intelsats II, III and, if necessary, *Early Bird*.

The large IV and IVA series have kept us going through the last decade with their capacities for 4000 circuits plus two TV transmissions (2000 more circuits for the IVA) each. Twelve out of fourteen were successfully launched.

In 1980 the last Intelsat III was taken out of service and in March of that year there were 12 operational satellites (seven IV and five IVAs). The latest generation, Intelsat V, handling 12,000 circuits and two TV transmissions each are now being launched (the first was last December).

As this decade wears on, the satellites will start failing as their 7 year design lives are exceeded - the batteries are a major limitation but a new version will hopefully stretch the lives beyond 10 years. INTELSAT hope to award the contract for five to eight vehicles (possibly leading to a total of 16) in March next year. The design should allow for launch by either the Shuttle or ESA's projected Ariane 4 rocket.

OTS IN FOURTH YEAR OF OPERATION

On 11 May the European OTS comsat began its fourth year in orbit. As a forerunner of a production series of comsats, the Orbital Test Satellite was built for ESA by a European consortium led by the Space and Communications Division of British Aerospace Dynamics Group. It was successfully placed in geosynchronous orbit on 11 May, 1978 on a three year mission as a pre-operational communications satellite to prove the technology needed for a subsequent series of satellites now being built.

British Aerospace is leading the same European consortium building five European Communications Satellites (ECS) and two MARECS maritime communications satellites. The first MARECS has been completed at Stevenage and is scheduled to be launched later this year. The total value of these seven satellites exceeds £110 million.

During its initial period of operation, various experiments were performed with OTS to provide practical proof of techniques never previously used before in any operational satellite service. Among the more important of these were: to relay signals by time division multiple access (TDMA); to use pulse code modulation; and to effectively double the bandwidth available for communication by re-using frequencies by dual polarisation of the transmitted signals.

Following the successful outcome of these experiments, OTS has since been employed in a pre-operational role to acquire operational experience of satellite communications. It has been used to demonstrate the capabilities of satellites for relaying TV programmes, TV video-conferencing and the high speed transmission of data between computers, as well as for carrying telephone and telex traffic.

During the design of OTS considerable emphasis was placed on reliability to ensure a long operational life. Results to date confirm the reliability of the many complex and interdependent systems comprising OTS. One transponder failed shortly after the satellite achieved geosynchronous orbit but for the last three years no other failures of consequence have occurred.

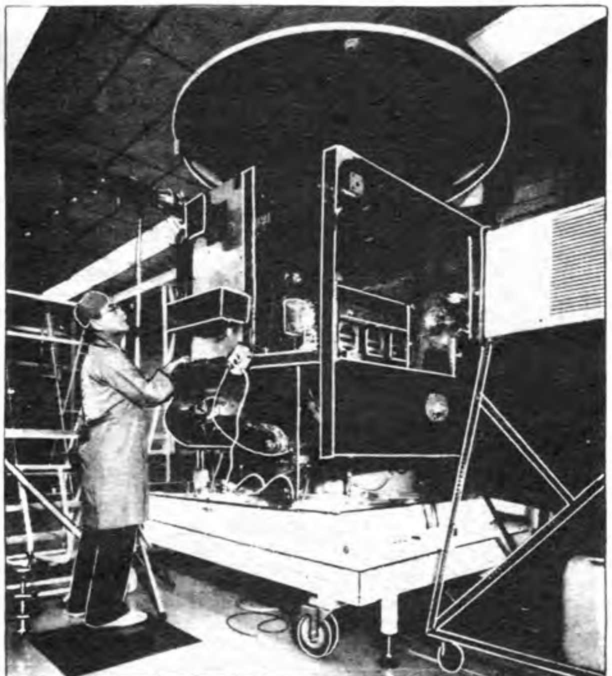
Although carrying very different communications payloads, ECS and MARECS are both derivatives of OTS. Further derivatives have been proposed to meet specific needs of other users including the UK Ministry of Defence for a military communications satellite.

INMARSAT/COMSAT/INTELSAT CONTRACTS

The International Maritime Satellite Organisation (Inmarsat) has signed a $5 million contract with Comsat General for a two-year lease of the space-segment capacity on Comsat's Marisat 2 (Pacific) satellite, beginning on 31 January 1982.

The Marisat satellites, launched in 1974, having been providing telephone, telex, facsimile and data services between ships at sea and land bases for the past four years. The lease arrangement will assure continuity of these services in the Pacific Ocean region and the contract has an option for Inmarsat to exercise a third year of service.

Three geostationary Marisat satellites were launched in 1976:



ESA will launch two Marecs maritime communications satellites for Inmarsat over the next year with its Ariane vehicle. Here, the first flight model is having an infra-red Earth sensor (for attitude control) checked at British Aerospace's Space and Communications Division. British Aerospace will provide the two craft and components for a third.

British Aerospace

Marisat 1	19. 2.76	(Atlantic Ocean)
Marisat 2	10. 6.76	(Pacific Ocean)
Marisat 3	14.10.76	(Indian Ocean)

Inmarsat, formed in 1979 to be responsible for maritime communications *via* satellite and presently with 35 member states, has also signed a $100 million contract with Intelsat in order to expand its communications capacity. Three of the new Intelsat V comsats, due to be launched in 1981/1982, will carry equipment for maritime communications, with the option on a fourth. The first Intelsat V, without the equipment, was launched last December.

On 27 November 1980, Inmarsat signed a contract with the European Space Agency for the lease of two Marecs satellites. The basic lease period of five years on each satellite can be extended for two years at Inmarsat's option. The satellites are being developed by ESA for launch on the Ariane vehicle in late 1981 and early 1982. Inmarsat plans to deploy these satellites for service to the Atlantic Ocean and the Pacific Ocean regions.

In March, Chile became the third South American state (the others are Brazil and Argentina) to join the maritime organisation.

BRITISH COMSAT PARTICIPATION

British Aerospace and Plessey have agreed to collaborate on defence communications satellite projects.

British Aerospace Dynamics Group has a long history of association with communications satellite programmes — since 1966 the Group has made major contributions to all of the Intelsat programmes which provide global communications *via* satellite. This experience enabled the Group to achieve the distinction of being the only non-American contractor involved in Comstar, the USA domestic communications satellite programme.

In Europe, the Dynamics Group has been chosen as prime contractor for all of the European Space Agency's communications programmes, commencing with the OTS satellites and continuing with a 'production line' of five European Communications Satellites for telephony, TV, data, facsimile and business communications, and two Marecs satellites for global maritime communications. The Group has most recently been chosen as prime contractor for L-Sat, a very large multi-purpose satellite capable of providing five channels of direct TV broadcasting to large countries.

The Group has also secured a major contract to supply equipment for three satellites for the French National Telecommunications Satellite Programme Telecom 1, satellites based on the British Aerospace design for the ECS satellite.

In all, this experience represents participation in over 45 communications satellites, ten as prime contractor.

In this collaboration, British Aerospace will provide overall leadership and be responsible for supplying spacecraft. Plessey will provide project support and be responsible for supplying Earth station equipment for monitoring and controlling the spacecraft and interfacing into terrestrial networks.

ARABSAT QUESTION

Space communications is a booming and potentially lucrative area for industry. Mr. Seligman, Euro-MP and a member of the European Democratic Group, recently tabled a question in the European Parliament on involvement in the proposed communications satellite for Arabian nations, Arabsat. He was concerned that EEC firms should be given every encouragement in the project since it would also lead to closer links between the Arab nations and Europe generally.

A BRIEF HISTORY OF THE VOYAGER PROJECT - Part 4

By Dr. J.K. Davies

Continued from the May issue

After launch on 31 August, 1977 Voyager 1 flew through the Jovian system in March 1979. During the encounter over 15000 photographs and a wealth of other scientific results were returned to the scientists on Earth. Voyager 2, launched earlier, but flying a slower trajectory, was due to arrive at the planet on 9 July, 1979 some four months behind its twin.

Introduction

As Voyager 1 receded from Jupiter, the scientific instruments aboard the spacecraft continued to look on the giant planet. On 9 April the spacecraft's attitude control jets were fired to adjust its course towards an encounter with Saturn, still nearly 800 million km away and 19 months in the future. During the flypast of Jupiter the spacecraft had been accelerated and swung onto course for Saturn by Jupiter's immense gravitational field, the planet's orbital energy increasing the spacecraft's velocity to about 84500 km hour. As the distance from Jupiter increased, Voyager 1 was commanded to settle into a relatively quiet cruise mode, sampling the interplanetary medium and carrying out regular calibrations and tests. Meanwhile, at Pasadena in California, mission controllers prepared for the arrival at Jupiter of Voyager 2.

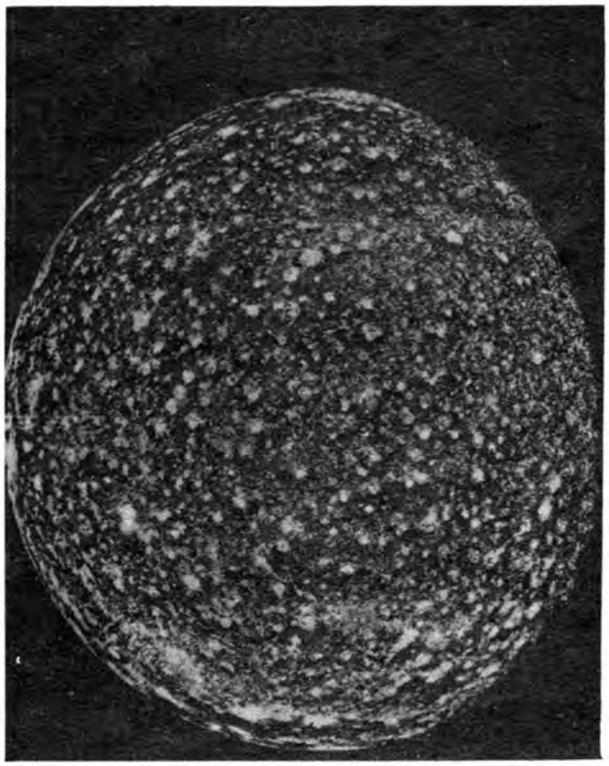
Voyager 2 nears Jupiter

On 24 April 1979, 76 days before the closest approach, and following a five day run of the events planned for the close encounter phase, Voyager 2 began Jupiter observations. The spacecraft was approaching Jupiter on a different sunline ~~to its~~ sister ship and would fly past the Galillean satellites on the inbound part of its trajectory. Since the satellites always keep the same hemisphere towards Jupiter this would help to improve the overall impression of the Jovian system by viewing the previously unobserved faces.

By early May, Voyager 2 was in its observatory phase and imaging Jupiter at two hour intervals. From these photographs another time lapse film of the circulation in the planet's atmosphere could be prepared. Comparison with a similar sequence taken by Voyager 1 would illustrate any large scale changes since March. As May turned into June it became clear that significant changes in the atmosphere had indeed occurred during the four months since the Voyager 1 flyby. Important changes were observed in the region of the Great Red Spot with movement of one of the previously observed white ovals relative to the Red Spot. The white oval was drifting east at a rate of 0.35 degrees per day while the Red Spot was drifting west at about 0.26 degrees per day. Other turbulent wave patterns observed since 1975 were also breaking up.

On 5 June, 34 days from closest approach, Voyager 2 was in good shape with only one or two minor worries for mission controllers. Of these, the most significant was the heating of one section of the spacecraft bus when the craft was manoeuvredoff the Sun line or when the power consumption changed. This heating caused frequency drifts in the one remaining radio receiver, limiting the ability of ground controllers to command the spacecraft. Events likely to cause the temperature variations were identified and plans for commanding the spacecraft during these periods were revised. The photo polarimeter instrument was also damaged; a stuck polarisation wheel giving problems similar to those encountered on Voyager 1.

After a two month long heat soak, designed to retard the degradation of bonding material, the infra-red interferometer spectrometer (IRIS) was successfully re-activated on 21 June. The IRIS was immediately put to use measuring temperature differences on the Jovian satellites as they disappeared into, and re-appeared from, Jupiter's shadow. Another IRIS task



A 9-frame mosaic of Callisto taken by Voyager 2 on 7 July 1979 from a distance of 390,000 km.

was study of the energy budget of certain satellites. The fields and particles experiments continued to sample interplanetary space as they had done during the long cruise between planets and were at last beginning to detect the presence of Jupiter.

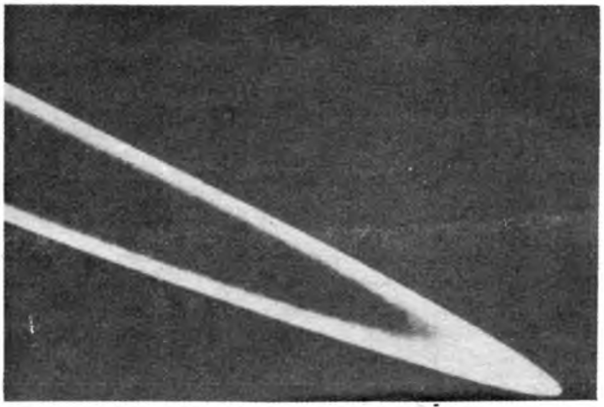
A final pre-encounter trajectory correction was made on 27 June finalizing the path through the Jovian system. Although the operations during the approach so far had been similar to those of Voyager 1, with imaging mosaics and daily scans with the ultra-violet and infra-red instruments, the details of the closest approach would be quite different.

Since the trajectory of Voyager 2 was designed to include a possible flight to Uranus (arriving in 1986), mission controllers wished to keep the spacecraft clear of the most intense parts of Jupiter's radiation field. Voyager 2 would flyby further from the planet than Voyager 1 and deeper into the southern hemisphere. This flight path would allow much higher resolution of the surface of Europa but would preclude a close flyby of Io.

Ten days from closest approach, Voyager 2 was 9.5 million km from Jupiter and travelling with a heliocentric velocity of 9.9 km/sec (22,000 mph). Jupiter's gravity would treble this velocity during the final approach to the planet and slingshot the spacecraft towards Saturn. One-way radio communication time was 51 minutes. At this moment Voyager 1 was 113 million miles from Jupiter, travelling with a heliocentric velocity of 23 km/sec and with a one-way communication time of 54 minutes.

Voyager 2 encounter

As Voyager 2 fell in towards Jupiter, the innermost satellites came under further intensive study. The spacecraft passed within 213,000 km of Callisto, twice the distance of the Voyager 1 flyby, but nonetheless returned many useful pictures of this heavily cratered world. Twelve hours later came the closest approach to Ganymede. Observations of Ganymede



Jupiter's ring, discovered by Voyager 1 in March 1979 and imaged here by Voyager 2 four months later.

showed bright young craters, light and dark terrain stripes resembling the outer rings of a large impact basin. Many bright and therefore young craters were observed, as were large areas of the grooved terrain first observed by Voyager 1.

Four and a half hours before closest approach to Jupiter Voyager 1 flew past Europa, the brightest of the planet's moons. Voyager 2 flew much closer to Europa than its predecessor and revealed a surface that was very smooth, with hardly any evidence of cratering. Europa appeared to be completely covered with a thin layer of ice, possibly overlying water or softer ice. Bright and dark linear features were interpreted as fractures in the crust through which ice was welling up to the surface. This continual resurfacing process would obliterate any impact craters almost immediately after they were formed, leaving an unmarked surface.

After Voyager 2 flew behind Jupiter it continued to look back on the satellite system, carrying out a volcano watch on the innermost Gallilean moon Io. Voyager 1 had discovered active volcanoes on Io and over a ten hour period on 9 July Voyager 2 took about 200 photographs. These would be used to produce a time lapse film of activity on the satellite. During this sequence the sunlit crescent of Io grew steadily thinner as the spacecraft flew deeper into Io's shadow until only a sliver of light, punctuated by the exploding plumes of the volcanoes, was visible. Of the eight active plumes observed by the first Voyager, seven were visible to Voyager 2 and of these six were still active. Only plume 1, the largest, had ceased erupting.

The day after closest approach a series of long exposure photographs of the recently discovered Jovian ring was taken. In these, the rings appeared much brighter than expected, probably due to forward scattering of sunlight by small particles within the ring. Within the main bright ring a fainter ring was observed. This inner ring appeared to stretch all the way down to the upper layers of the planet's atmosphere. Several more images of the rings were obtained the following day as the spacecraft looked back onto the night side of Jupiter searching for auroral activity and lightning. From these the dimensions of the ring were estimated at about 65000 km wide and less than 1 km in thickness.

In addition to the intensive study of the satellites and the ring system Voyager 2 continued to record vast quantities of information about the electromagnetic and particle environment around the giant planet and returned additional thousands of images of the atmosphere. On 9 July, and again on the 23rd, trajectory corrections were carried out to point the Voyager towards its rendezvous with Saturn in mid-1981.

Throughout the flyby the radiation levels detected by Voyager were higher than expected and these led to several problems with the craft. In addition to the expected difficulties in transmitting commands *via* the damaged radio receiver, the photopolarimeter instrument also suffered radiation damage. This instrument has three filter wheels (aperture, filter and polarisation) and although the polarisation wheel was not operated because of problems earlier in the flight, it had stepped several positions from the position in which it had been left. The filter wheel was also damaged, it was skipping every other position, reducing the number of filters available for observations.

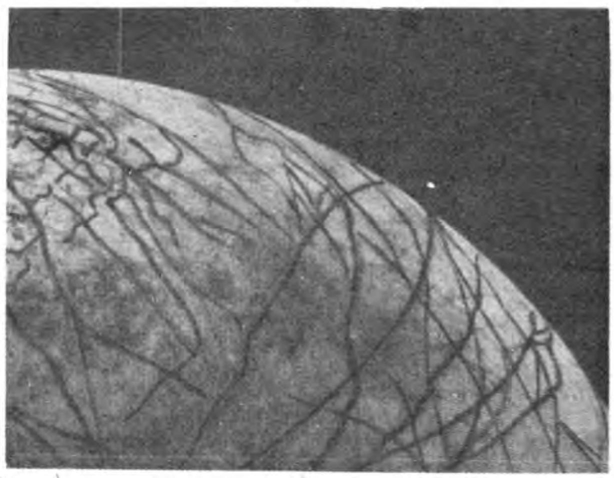
Despite these minor problems, the second Voyager encounter had also been a tremendous success and with solar conjunction approaching at the end of July a fairly quiet period followed at mission control in Pasadena. During solar conjunction the Sun was between the two Voyager's and Earth so radio communication was difficult. This did, however, give scientists a chance to study the effect of the Sun's electromagnetic fields on the radio signals. This period of reduced activity lasted about six weeks until the middle of September.

Pioneer 11 and Saturn

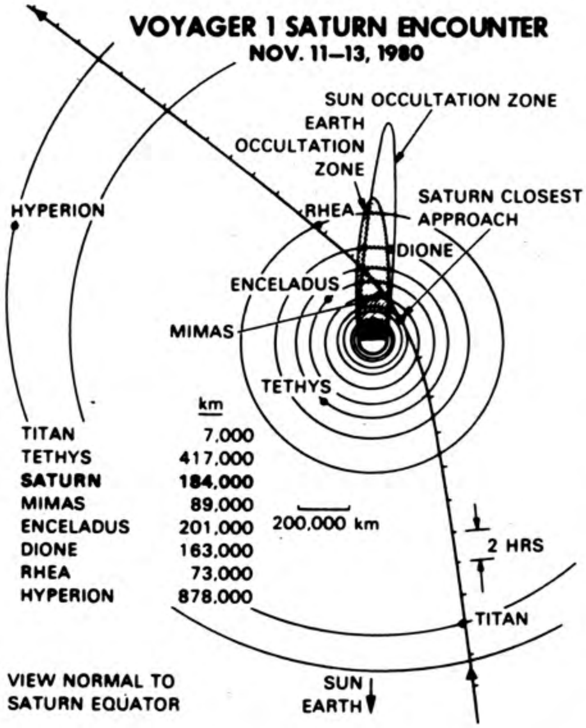
While the two Voyagers were having a well earned rest between planets, another milestone in planetary exploration was approaching. Some seven years after leaving Earth, Pioneer 11 was closing in on Saturn. The 258 kg Pioneer and its mission have been described in detail in previous issues of *Spaceflight* and so only a summary is given here. Pioneer 10 was the first spacecraft to investigate Jupiter, and the essentially identical Pioneer 11 was launched almost a year later. Spin stabilised and with relatively unsophisticated instruments, Pioneer 10 blazed a trail through the Jovian system which allowed mission planners to take a daring gamble with its sister ship. Pioneer 11 flew closer to Jupiter, passing through the planet's intense radiation field more quickly, and was swung back, almost upon itself, onto a trajectory for Saturn. The coast across the Solar System lasted five years and by the time Pioneer 11 reached Saturn it had exceeded its design life by 40%. NASA was hoping that like previous Pioneers the spacecraft would continue to operate well beyond its nominal lifetime.

This optimism was justified, for as Pioneer 11 approached Saturn in August 1979 it was indeed in good condition, a tribute to the engineers who had built it and to the controllers at Mountain View, California who had nursed it throughout its monumental journey. On 1 September 1979, while NASA held its breath, Pioneer 11 swooped down past the outer edges of Saturn's rings, past the cloud tops and up, out again towards deep space with hardly a jolt to its systems.

Details of the scientific results from the encounter are given



The surface of Europa is apparently covered by a thin layer of ice, criss-crossed by fractures.



in refs. 1 and 2 and will not be further discussed in this text. The findings did, however, greatly influence planning for the Voyager 1 encounter with Saturn, just over 13 months away.

During the flyby vital navigational data had been gained and it had been shown that damage to Voyager 1 from radiation or ring particles was unlikely, strengthening hopes that Voyager 2 would ultimately fly on from Saturn to Uranus. The Uranus option would be exercised only if Voyager 1 achieved all of its objectives at Saturn; failing this Voyager 2 would be re-assigned to these tasks. If this happened a flight to Uranus would no longer be possible.

With the excitment of the Pioneer 11 flyby over, mission operations slipped back into a routine as the two Voyagers cruised across the abyss between the Solar System's largest planets. Analysis of results from the Jupiter flyby continued and a further two Jovian moons were discovered, the second while searching for confirmation of the first. Instrumental in the discoveries were G. Edward Danielson of the Voyager imaging team, optical navigation engineer Steven Synnott and David Jewitt, a Cal. Tech. graduate student.

Voyager approaches Saturn

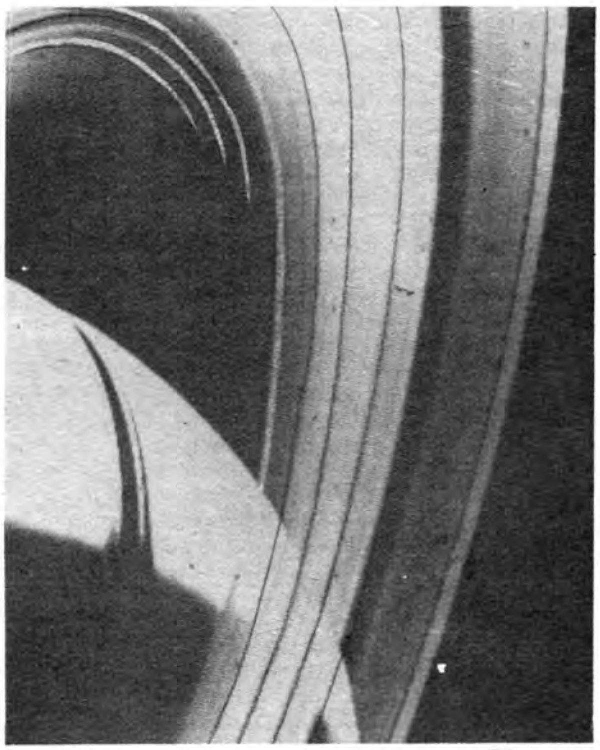
On 16 October this routine was abruptly disturbed when contact with Voyager 1 was temporarily lost. After a 22 hour cruise science manouevre, which is performed in radio blackout since the main antenna moves off Earth line, radio signals did not arrive back on Earth when expected . This was because after the series of turns allowing the scientific instruments to scan the whole sky, the spacecraft's star tracker had locked onto Alpha Centauri instead of Canopus and the high gain antenna beam was no longer pointing at Earth. Once the situation was understood, the powerful 80 kW power carrier at Tinbinilla in Australia was used to command, through a sidelobe of the spacecraft antenna, a switch over to the low gain antenna with its larger beamwidth. This done,passing commands to the Voyager was easier and the spacecraft was instructed to roll 56.8 degrees, resulting in Earth-pointing the antenna and placing the star tracker within 1 degree of Canopus. On ce the signal from Voyager was recieved at Earth, Voyager 1 was commanded to re-acquire Canopus and return to its high gain antenna. The emergency was over.

1980 dawned another year, and with it another award for the Voyager team. In 1979 the American Veterans of Foreign Wars had presented their National Space Award Gold Medal to the Voyager project and on 24 March, 1980 President Carter presented the National Space Club's Goddard Memorial Trophy, America's most prestigious space award, to the project. The President said "The team that's made this flight possible ...... deserve the highest accolades".

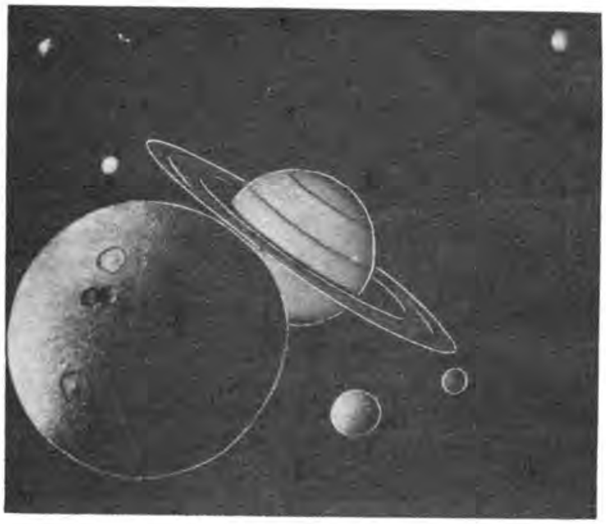
Voyager 1 had already begun to take photographs of Saturn for calibration and navigation purposes even as the president spoke, although at ranges of over 300 million km little detail was visible, even after computer enhancement. By May both spacecraft were on target and in basically good health, although some internal inconsistencies between the two computer command subsystem processors on Voyager 1 were causing a little anxiety. Four command anomalies had been noted on Voyager 1 since the encounter with Jupiter and a team was set up to investigate possible fault protection measures. Voyager 1 would move off Earth line several times before arriving at Saturn and it was vital that the high level of internal command activity during these events should not predjudice the mission.

As a precaution against the failure of the remaining receiver onboard Voyager 2, the backup mission load (BML) stored in the spacecraft's computer was updated. The new BML would activate if contact with Earth was lost and would extend the data gathering capability beyond Saturn to Uranus.

During July and August, as the distance to Saturn decreased, mission controllers underwent a seven week test and training period. A variety of simulated emergencies, including a fire in the mission control area during commanding were sprung upon controllers without warning. This ensured that the long planetary coast had not dulled the skills of the scientists and



Saturn's rings as Voyager 1 begins to move away. The main body is clearly visible through the A, B and C rings.



A montage of Voyager 1 images of the Saturn system. Starting at top right and going anti-clockwise, we have Titan, Rhea, Enceladus, Dione, Tethys and Mimas, with Saturn itself in the centre.

engineers at Pasadena. Test and training climaxed on 18-19 August with the near encounter test, a simulation of the activities during the closest approach to Saturn. During the test a near-duplicate of the encounter computer sequence was sent to Voyager 1 and activated. Over the portion of the test simulating occulation of the Sun by Saturn, alternate pointing commands were supplied to the scan platform, lest the cameras be damaged by pointing directly at the Sun.

On 22 August, 82 days before closest approach, Voyager 1 began its observatory phase studying the planet from a range of over 100 million km. At this point the spacecraft was 1.4x10 km from Earth and travelling at 20.4 km/sec. One way light time was 80 minutes. Apart from minor problems with the star tracker and the pointing accuracy of the scan platform, Voyager 1 was in good health for its encounter.

Saturn Encounter

The Saturn encounter was divided into five major phases beginning with the observatory phase. During a nine week period a long time base history of the Saturn system was compiled. At long range the battery of scientific instruments on the Voyager were brought to bear on the mysteries of Saturn. Seven times a day the ultraviolet spectrometer swept across the planetary system, searching for clouds or tori of ions in the orbits of the planet's moons and investigating their chemical constituents. The atmosphere, thermal structure and dynamics of Saturn were investigated by the infra-red spectrometer and radiometer aboard. Twice daily radio-astronomy scans, returned to Earth at 115.2 kilobits per second, defined the radio rate of rotation of Saturn to be 10 34.4m. This compared well with the value measured from Earth for polar and temperate regions, but was longer than the previous result (10h 14m) for the equator. This indicated the presence of a high velocity equatorial jetstream suggested by Pioneer 11. Fields and particles experiments aboard Voyager 1 were also active, studying interplanetary space in the vicinity of the giant planet.

The most obviously spectacular results, however, were coming from the TV cameras on the spacecraft. Photographs were taken at approximately 2 hour intervals, one fifth of the rotation period, every day. From these, time lapse movies would be made which would appear as zooms towards five specific longitudes on the planet. In addition, during a 42 hour period on 12-14 September the planet was imaged continuously every 4.8 minutes. These images were taken through a set of 3 different colour filters every 8 degrees of rotation and from them a colour film of four rotations of the planet was prepared.

The intensive imaging showed less detail in the atmosphere of Saturn than had similar footage of Jupiter for a variety of reasons. Saturn was revealed as a less active planet than Jupiter and much of the detail within the atmosphere was masked by high altitude clouds. In addition, the range at which these images were recorded was more than twice the distance for comparable photographs of Jupiter. The reasons for this were twofold, firstly the photographs were intended to capture any motion within the planet's rings and, secondly, Voyager 1 was rapidly approaching its annual solar conjunction, which would interfere with data transmissions. Solar conjunction occurs when the spacecraft, as seen from Earth, appears to pass behind the Sun. When the angle from the Sun to Voyager and back to Earth is less than 5 degrees the intense activity within the solar corona seriously interrupts communications with the spacecraft. This period lasted for about 2 weeks during the middle of September for Voyager 1. Although this interfered with the scientific and engineering data flow from the spacecraft it did give the radio science team an opportunity to study the solar corona and make certain measurements crucial to Einstein's theory of relativity.

As Voyager 2 rushed towards Saturn, the detail in the photographs of the planet grew steadily better. On 17 September, 1980 the distance to the planet had shrunk to 75 million km and picture resolution had increased to about 1600 km, three times better than the best picture ever taken from Earth. Most of the major satellites were clearly visible and from these photographs would come more detailed calculations of their paths around Saturn. The search for new moons had also begun; long exposure photographs through the clear filter were trying to capture a variety of suspected satellites.

From 50 million km, previously unobserved features were seen in Saturn's rings and, as was to be the pattern throughout the encounter, scientists were caught by surprise. Clearly visible in the inner B ring were dark spoke-like features which rotated around the planet. Some of these features were observed to persist for three or more hours despite the differing orbital velocities between inner and outer edges of the ring. These spokes should have been rapidly erased as the inner edge of the ring raced ahead of the outer portions. Although individual markings within the ring did indeed disappear in a few hours, new features seemed to be continually regenerated by an unknown mechanism.

On 24 October Voyager 1 entered its far encounter phase and over the next day took its last non-mosaic images of the planet. For two months Saturn had been growing in the field of the camera and now a single frame could no longer capture the whole planet. During the far encounter phase, regular 2x2 three colour mosaics were made, supplemented by additional images of the rings. Infrared and ultraviolet data were also collected, the ultraviolet spectrometer attempting to gain information about the composition of Saturn, its rings and inner satellites.

Over a ten hour period on 25 October the rings were imaged every 4.8 minutes to provide a time lapse motion picture of the radial features forming and dissipating. These photographs revealed two new satellites, satellite 13 orbiting about 2500 km beyond the outer Fring and satellite 14 between the F and A rings. Both satellites were small, only 2-300 km in diameter.

On 2 November, Voyager 1 entered its far encounter II phase with only ten days remaining to closest approach, and detail of amazing complexity rapidly becoming evident in the rings. The army of scientists, engineers and journalists at Pasadena waited amid rising excitment for close up photographs of Saturn and its mysterious moons.

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HALLEY'S COMET — M

WHY IS HALLEY IMPORTANT?

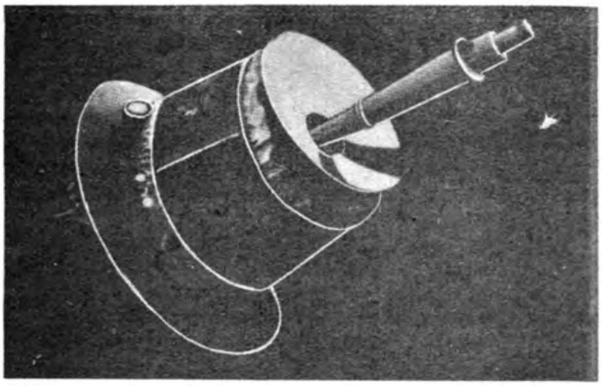
The apparition of Halley's comet in 1986 is one of those rare events whose anticipation by the popular mind is matched by the attitude of the scientific community. Three generations seperate us from the last apparition in 1910 and the capability of astronomical investigation has increased enormously in that time. There exists a number of competing hypotheses concerning the origin, evolution and constitution of comets, and indeed of the Solar System, which a detailed investigation of Comet Halley will assist in resolving.

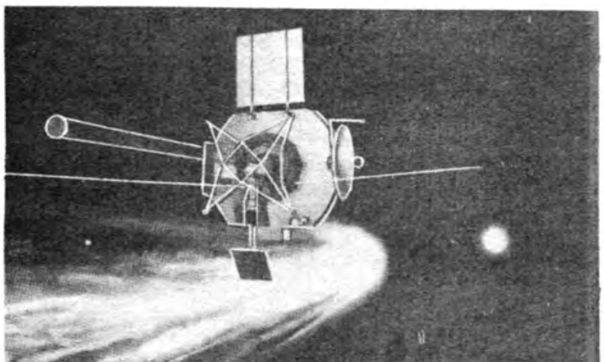
In order to take advantage of this opportunity three missions to Halley are planned: by ESA, Japan and the USSR. Planners in the US have designed a Halley Intercept Mission, presently unfunded.

The typical picture of a comet as it nears perihelion consists of a small nucleus, 1 to 10 km in diameter, surrounded by an atmospheric coma perhaps 10^5 km in diameter and one or more tails which may extend tens of millions of kilometres, generally in an anti-Sun direction. Halley is particularly important because it is still a relatively young, active comet with a well-known history and orbit.

Comets may be more important than we previously thought if theories concerning the origins of life on Earth are correct. Astronomer Fred Hoyle has suggested that "the molecules of life have reached this planet through the addition of cometary and meteoritic materials."

Halley's Comet in May 1910 during its last apparition. This time it will receive visitors from I





Above: the European Giotto Halley probe is the best project yet funded but it has its limitations. The Jet Propulsion Laboratory have been pushing for a much more sophisticated American craft, but as yet it is not funded, *below*.

HALLEY — MAN AND COMET

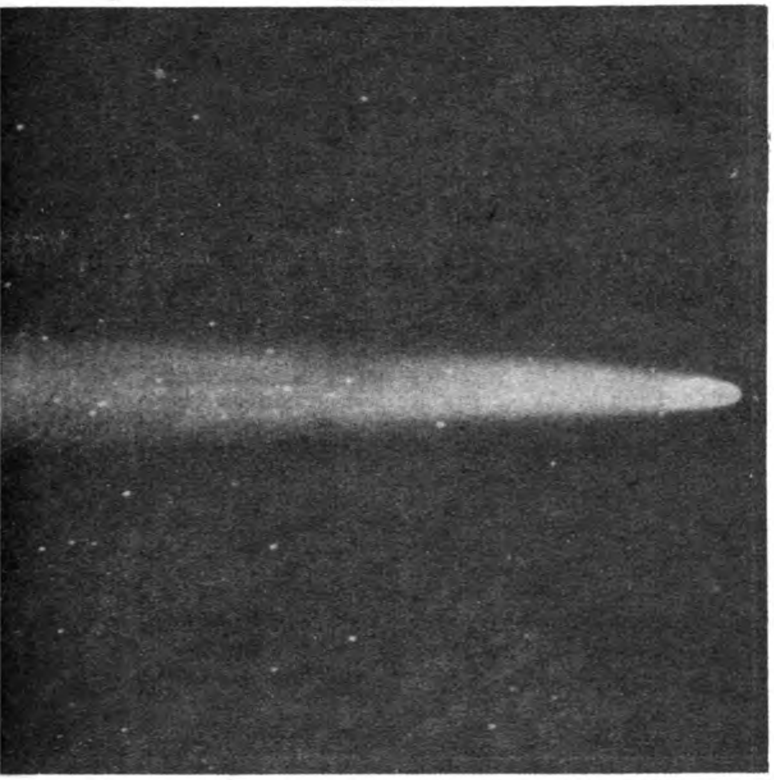
The most famous dynamical analysis of Halley's orbit was, of course, that by Halley himself in the first significant application of the newly-developed methods of Isaac Newton. Prior to Halley, progress had been made concerning the nature and motion of comets. Tycho Brahe's typically accurate observations and data analysis of the bright comet of 1577 established that comets were more distant than the Moon and not an atmospheric phenomenon.However, Tycho placed the comet in a circular path and up to the time of Newton the form of the orbit remained uncertain.

In 1695 Halley began the task of determing the orbits of 24 comets for which observational material was not available. Despite the aid of Newton's methods this was a task involving an enormous anount of labour and difficulty. The discipline of orbit determination was in its infancy and a comet is a particularly difficult object since it can only be observed over a short arc of its orbit. Add to this the relatively primitive state of positional astronomy and it is not surprising that Halley's work on cometary orbits, *Astronomiae Cometicae Synopsis*, did not appear until 1705. Therin was contained the prediction of the return of the great comet of 1682 (and 1607 and 1531 .... ie., Halley's comet) in 1758.

Halley died in 1742, a famous man. He had been Astronomer Royal and one of the premier scientific minds of his age, making contributions not only in astronomy but also in geophysics, meterology, navigation, mathematics and engineering. It was for his wide range of achievements that Halley was valued by his contemporaries and by immediate posterity. But after the return of the comet in 1758, a replacement process has resulted in the association of his name almost exclusively with that particular 'hairy star'. History could have been less kind.

We now know, of course, that the comet of 1066 was Halley's and observations of it stretch back to 240 BC. Some of us may even see it on its appearance in the 2060's!

ESSENGER FROM SPACE



Hale Observatories

THE PROBES

In July 1980, ESA approved the building of Giotto and it is being built by British Aerospace. The 750 kg craft, based on the proven European *Geos* satellite design, is aiming for a launch on 10 July 1985 and a fly-by on 13 March 1986. Unfortunately, Halley is in a retrograde orbit so the approach velocity will be 68 km/s and the probe will cross the tail in about 90 minutes. As it goes, it will photograph the nucleus (the distance will depend on flight path accuracy but the camera can provide a resolution of 50 m from 1000 km away) and sample the material in the tail.

The Japanese will make their first attempt at a deep space flight with 'Planet A' launched by one of their own rockets. This limits them to a 10 kg science payload (ESA's will use the Ariane 2 launcher to carry 53 kg) consisting of an ultra-violet camera and magnetometer. Closest encounter will be about 10,000 km.

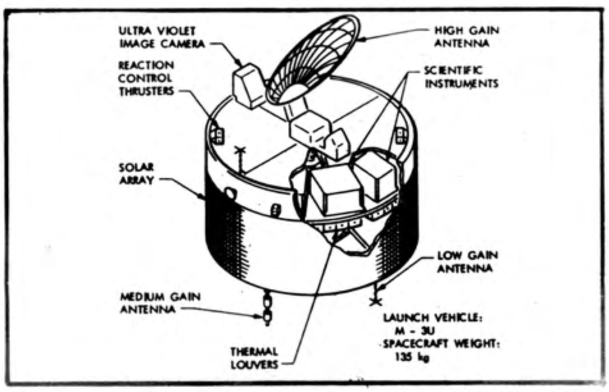
The Soviets will convert at least one of their 1984 Venus probes so that it will leave its first target and travel to meet Halley. Since they are basically Venus craft they cannot carry heavy shielding and will have to pass no closer than 10,000 to 50,000 km in order to avoid the dustier regions.

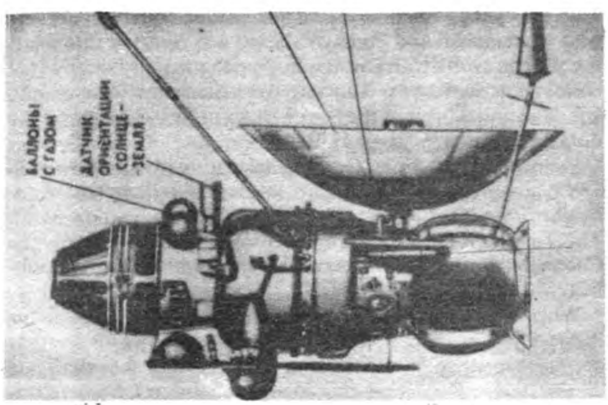
The proposed American craft would carry 115 kg of experiments, but no funding has been provided.

This material has been adapted from Bill McLaughlin's comprehensive paper 'The Natural History of Halley's Comet' published in the July issue of ***Space Chronicle.***

HALLEY DATA

● Earliest probable recorded apparition	240 B.C.
● Number of recorded apparitions (the 164 B.C. apparition was not recorded)	28
● Shortest period between returns to perihelion	74.42 years (1835-1910)
● Longest period between returns to perihelion	79.25 years (451-530)
● Closest approach to Earth	0.04 AU (April 11, 837)
● Longest angular tail recorded	93° (mid-April 837)
● Brightest apparent magnitude recorded (approximate)	3.5 (April 11, 837)
● Next perihelion passage	February 9.66128, 1986 E.T.
● Perihelion distance	0.5870959 AU
● Eccentricity	0.9672671
● Argument of perihelion	111.85336 deg
● Longitude of Ascending Node	58.15313 deg
● Inclination	162.23779 deg
● Orbital velocity at perihelion	54.55 km/s
● Orbital velocity at aphelion	0.91 km/s
● Estimated diameter of nucleus	5 km
● Estimated density of nucleus	1 g cm^{-3}
● Estimated rotation period	10.3 hours
● Observed spectra in 1910	CH, CN, C_2, C_3, Na, CO^+, N_2^+





Above, the Japanese 'Planet A' is the smallest of the Halley probes (only 10 kg of experiments) while the Soviet 1984 Venus probes, *below*, is not designed primarily for the comet mission. Shown here is the 1967 Venera 4.

SALYUT 6 MISSION REPORT : Part 7

By Neville Kidger
Continued from March issue.

Early in 1978 four pilots arrived in Zvezdny Gorodok for evaluation as cosmonaut trainees. As with all of the CMEA cosmonaut candidates the Soviets had the last word as to who would be selected. The four men were from the communist island of Cuba and were the first representatives of the western hemisphere to be evaluated for flight aboard a Soviet spaceship (2 French pilots have since been selected and began training at Zvezdny on 7 September 1980 for the flight one will make to a Salyut station early in 1982).

Eventually two of the Cuban pilots were chosen for training. Both of them served together in the same air force unit in Cuba. In September 1979 they were introduced to the two Soviet cosmonauts with whom they would train for one of the crews to make a flight.

Although their identities were closely kept secrets at the time the two crews consisted of: Soviet cosmonaut Yuri Romanenko and Cuban Arnaldo Tamayo Mendez, 38, and Evgheni Khrunov (USSR) and Jose Armando Lopez Falcon (Cuba), 30. Tamayo was the first black person to be selected for a Soviet spaceflight and the first black ever to fly into space.

After 12 months of joint training the two crews departed for the Baikonur Cosmodrome on 4 September 1980 after a 2 hour long press conference for CMEA journalists. The launch date was set for 18 September. After the final examinations the Romanenko/Tamayo team was selected.

Late on 18 September the yellow and white autobus with Romanenko and Tamayo aboard stopped at the launch pad and the Taimirs (their call sign) stepped out into the full glare of the TV lights. After their usual round of set speeches the cosmonauts met, and posed for photographs with, Cuban Minister of the Armed Forces Raul Castro Ruzz who had visited the training centre at Zvezdny the day before. As the Taimirs boarded the Soyuz 38 spaceship on the A-2 carrier rocket, some 2 hours before launch time, the Dniepers (Popov and Ryumin) were contacted by FCC and told to expect new visitors.

The 18 September launch date was unusual because it came about 2 windows, or 4 days, earlier than normal. Despite the exotic theories to explain this divergence from past procedure by some Salyut observers the reason was probably simply to ensure optimal lighting conditions for the Earth resources cameras during the flight.

Soyuz 38 in Flight

At exactly 1911:03 (all times GMT), 18 September, the engines of the carrier rocket ignited and the Soyuz 38 flight was underway. Following a nominal launch phase the Soyuz 38 spaceship with Romanenko and Tamayo aboard was inserted into near-Earth orbit at 1919:50. During the launch the pulse rates of the cosmonauts had been: Tamayo 120 beats/min; Romanenko 102. The initial orbit of the Soyuz 38 was 199 x 273 km and the distance to Salyut 6/Soyuz 37 10,000 km.

Following corrections to the trajectory with the Soyuz 38 SKDU on the 4th and 5th orbits the orbital parameters were: height 278 x 320 km; period 90.2 minutes; inclination 51.6°. The Taimirs then settled down to sleep while on Earth the Cuban and Soviet media announced the flight amid great publicity.

When the Taimirs awoke on 19 September the Salyut-Soyuz distance was only about 1,000 km. Shortly afterwards another approach maneouvre was made and the distance shrank to just 23 km before the actual approach was initiated. Soyuz's antenna activated the short range automatic coupling systems as this distance shrank further. Distance was automatically measured and the Soyuz TV camera focussed onto the station's navigation lights with the cosmonauts reporting every step of the operation. At 45 metres distance between the ships the approach velocity was 0.6 m/s. Contact was made at exactly 2049 at a velocity of 0.3 m/s. The coupling latches of Soyuz joined the ship's together with a force of about 20 tonnes.

Pressure was equalised between the ship and station by means of the internal hose and some 3 hours after the docking, at 2352, Tamayo broke open the internal hatches and floated into Salyut to be enthusiastically greeted by Popov and Ryumin. For the FE the fourth meeting with another crew in space must have been a stark contrast to his 175 days of comparative loneliness with Lyakhov on the last flight. At the time of the transfer Salyut was making its 17,128th orbit of the Earth. In a TV report, which included the traditional bread and salt ceremony and exchanges of telegrams with Soviet and Cuban leaders, both Romanenko and Tamayo performed somersalts to show how they had adapted to weightlessness. Both crews then settled down for sleep before beginning their week of experiments.

Aspects of Orbital Flight

September 20 was a short working day, because the doctors wanted to keep as close as possible to the 0800 - 2300 (MT) timeline the Dniepers were following; so the Taimirs started several experiments, including the Sugar, Zone and medical ones. Tamayo complained to a doctor that he was not feeling as well as he had done on either of the previous two days. The doctors advised him not to rush about the station but take things easy for a while. Following that sound advice Tamayo settled down to orbital life, slept well and demonstrated a healthy appetite with a calorie intake of 3,500 to 3,800 calories/day. He also appeared cheerful with a high work capacity, according to the FCC directors.

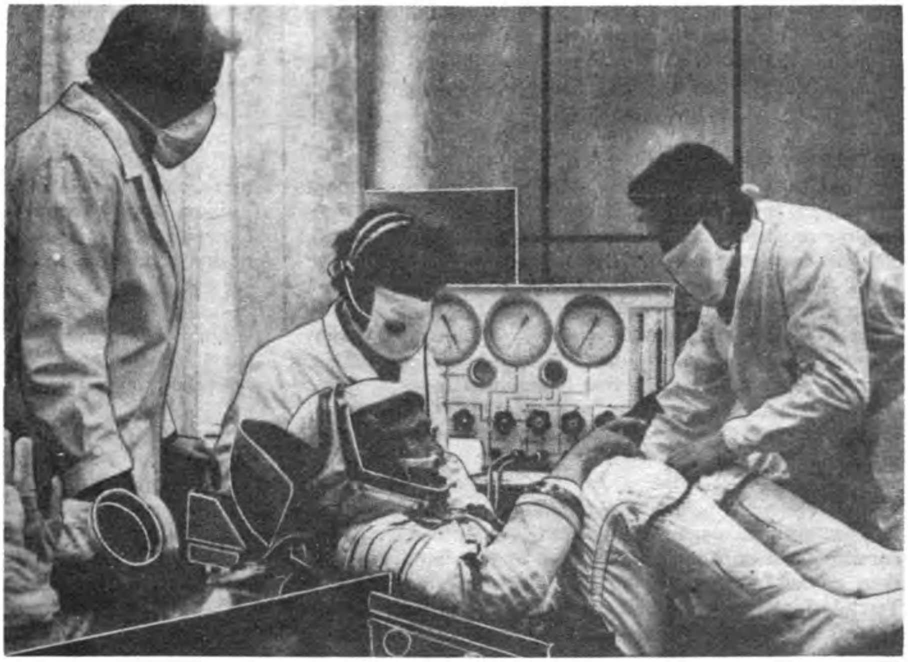
By the fourth day of the flight Romanenko had grown by 2cm (because of the expansion of fluids in his spine). But his new-found stature would last only until he was back on Earth. Doctors puzzled over the fact that Tamayo's blood vessel content had been less than that which is normal for cosmonauts during adaptation to weightlessness.

Looking down on Cuba, which Romanenko said had reminded him of a large fish with fins, Tamayo said that he thought it a wonderful sight. There were no clouds, the sky was clear, the sea looked very beautiful. Later he was able to see the night lights of Havana.

Experiments on Salyut 6

Of course, sightseeing was only for off-duty periods. Most of the Taimirs' time aboard the station was taken up with the various experiments they had brought with them. In daily TV

Prime crew for Soyuz 38. *Left,* Lt. Col. Arnaldo Tamayo Mendez of Cuba; *right,* Yuri Romanenko.



Leonid Popov undergoes a last medical and spacesuit check before launch to Salyut 6. He and Ryumin returned to Earth on 11 October 1980 after a mission lasting 175 days - more than double the US record of 84 days held by the Skylab 4 astronauts.
All pictures courtesy Novosti

broadcasts the crew showed the apparatus to viewers and described its function. In all there were 27 experiments, some designed by Cuban specialists. The experiments were grouped under the headings of medical/biological, psychometric investigations, exploration of natural resources and technological research.

The Cuban experiments, described below, were first conceived in late 1977. Seven administrative agencies, over 50 research institutes and factories and almost 500 technicians and workers (many having no idea what purpose their work would serve) brought the plans to fruition.

Medical/Biological Experiments

CORTEX: An experiment designed to study the brain's electrical activity in weightlessness. The human brain produces about one millionth of a volt in electrical output which is monitored to evaluate the neuro-phsychic state of the subject *via* an electroencephalogram (EEG). This technique is routine in neurological science. A baseline EEG was obtained preflight of the cosmonaut subject's reactions to stimuli for comparision with in-flight and post-flight EEGs.

The Cortex hardware consisted of a custom-made latex helmet, high grade silver electrodes, earphones, light and sound stimulators, amplifiers to measure the EEG and a 4-track tape recorder. All were stored in a smart leather case.

In operation an EEG recording was made from one cerebral hemisphere at a time when the cosmonaut subject was either resting or performing simple mental arithmetic. EEGs were also obtained of visual and auditory evoked potential (EP) which is a measure of the brain's electrical activity. The visual EPs were obtained by watching a flashing light.

SUPPORT: In this experiment Tamayo was required to wear, for 3 to 6 hours a day, a specially designed adjustable shoe - the Support Sandle 501 - to place a load on the arches of his foot "to determine the recovery and readaptation of locomotive stability on return normal gravity conditions." It had been noted that on return to Earth after long flights cosmonauts had a tendency towards *platypodia,* especially under load. The changes in gait and posture were attributed to a change in muscular tension. By placing a tension on Tamayo's feet Cuban specialists aimed to determine whether changes in the arches of the feet were important in the disturbance of posture after return to Earth. As a control Romanenko did not wear the shoes. The experiment is to be repeated in future long-duration flights.

ANTHROPOMETRY: An experiment with the objective of determining the changes in muscular mass and bone structure in weightlessness by use of the Kosmos 726 Calipers to examine adipose tissue and to stimulate it.

BLOOD CIRCULATION: A series of electrocardiograms taken before, during and after the flight determined the bioelectrical alterations of the heart during adaptation to weightlessness and readaptation to 1G. The experiment involved monitoring the blood circulation. The Pneumatik 1 and Chibis suit devices were used to simulate 1G during the flight to characterise the adaptation and counteract the feelings created by blood rushing towards the cranial region.

A series of tests and samples were made before the flight and immediately afterwards to determine the cosmonaut's adaptation to, and the effects of, weightlessness. In the *VISION* experiment the clinical and functional states of the cosmonauts eyes was determined by an opthalmic investigation common to all Soviet flights but with new parameters added by Cuban specialists. The *BALANCE* experiment aimed at determining changes in Tamayo's hydro-mineral balance and comparing them with Romanenko's to determine any differences between a cosmonaut from a European climate and one from the tropics. The test series included water intake, urine excretion, body weight and blood tests to determine the content of sodium, calcium, magnesium, chlorides, creatine and other substances. The *IMMUNITY* experiment was aimed at the determination of characterising the changes in proteins and minerals directly related to the body's natural defences during spaceflight. Blood samples obtained before and after the flight were analysed for the content of immuniglobin, antibodies and other proteins and minerals involved in immunological reactions. Finally, the *STRESS* experiment determined changes produced in Tamayo's hormonal characteristics and carbohydrates and lipid metabolism.

Microbiological investigations were represented on the flight by two investigations which used yeast as the study organism. Yeast was selected because it is a single cell micro-organism

with a short life cycle thus allowing several generations to be observed developing in weightlessness. The *HAUTEY* experiment studied how the yeast cells divided and the *MULTIPLIER* experiment involved a study of the growth and multiplication of the micro-organism.

Technology Experiments

SUGAR: (although it might be classed as a biology experiment the Cubans termed sugar a technological one. That classification is retained here). It consisted of monitoring the growth of a sucrose mono-crystal in the crystallizer device built in Cuba. The device (weight 400 grammes, volume 970 cm^3) comprised a chamber containing four crystals submerged in different solutions which were grown for 72 hours and photographed periodically with the GDR-made praktika EE-2 manual camera. It was the first experiment to grow single crystals of an organic compound in space. On TV Tamayo said he was surprised to see how fast the growth of the crystals had been.

ZONE: This experiment aimed at simultaneous studies of the dissolution of sucrose mono-crystals using a novel technique consisting of dissolving a solid material within a liquid area and then crystallising it using different temperature gradients. Tamayo displayed one of the containers for the experiment on TV showing three sucrose crystals inside it.

A more traditional series of smelting experiments was conducted under the code name *CARRIBE.* The aim, as usual, was to obtain semiconductor crystals and examination of the nucleation and growth mechanisms of crystals of differing insulating properties. The Splav and Kristall furnaces were both used in the experiment which had 5 separate smeltings.

S-1 : growth of epitaxiel layers of gallium arsenide alloyed with aluminium
S-2 : smelting of tin-telluride and germanium-telluride alloy;
K-1 : alloying of a germanium monocrystal with indium;
K-2 : as S-1 but with a different method;
K-3 : alloying of zinc-indium-sulphide.

Spectroscopy of the Salyut windows was also conducted in the ILLUMINATOR experiment utilising the Spektr-15 instrument.

Psychometric Experiments

COORDINATION: Study of the effects of weightlessness on voluntary motor function was the basis of this experiment. Pre-flight and in-flight results were compared of a simple test to assess the psychomotor ability of Tamayo. A Cuban-built Coordinograph was used for the test. By turning two cranks simultaneously, one with the left hand one with the right, Tamayo had to guide the point of a crayon between the double outline of a geometric figure without touching the line, at varying speeds.

PERCEPTION: With Cuban-built equipment based on commercial models this experiment evaluated the visual, tactile and muscular sensitivity of Tamayo.

QUESTIONNAIRE: By answering a series of set question throughout the flight psychologists could assess the cosmonauts' reactions and mood, including behaviour. Questions ranged from "how are you adapting?" to specific aspects of the flight.

REST: Results of the rest experiment directly influenced the Questionnaire experiment. It has become common practice for Interkosmos crews to take a pre-prepared video tape to Salyut and play it during rest time. The tapes contain such items as cultural and personal scenes, much of it unknown to the subject. The degree to which it relaxes the subject is assessed *via* the Questionnaire. The Rest experiment and Questionnaire experiment are part of the basic experiment programme for all the main Salyut crews.

The Taimirs' Return

In addition to their experiments the Taimirs also aided the Dniepers in the first round of their preparations for returning to Earth. Because the main crew were scheduled to return by mid-October (specifically stated by a Soviet spokesman) the Taimirs were not required to leave their Soyuz 38 ship for the Dniepers and return in Soyuz 37. Because of this the time normally taken in exchanging seats was used to pack some of the experiment results into Soyuz 38 from the main expedition as well as their own.

On 25 September, just 24 hours before their return, a short burn was conducted with the Soyuz 38 SKDU to check its operation and refine the reentry track. Soyuz 38 would land about 2 hours after dark in Kazakhstan.

Early next morning (26 September) the crew had breakfast and bade farewell to the main crew. The send off was slightly more emotional than usual. At 0925 the Taimirs crossed into Soyuz 38 and closed the hatches. They donned their spacesuits and conducted the normal series of pressurisation checks. At 1234, over the Soviet Far East, the two ships parted. The separation manouvre was performed and the Taimirs watched Salyut 6 slowly drift away.

On the last orbit before retrofire, in accordance with tradition, Vladimir Shatalov told the crew about their duties after entry into the atmosphere. He reminded them that they were to be patient if the helicopters were a little late in reaching them. It would be after dark and the helicopters would have to look for them with searchlights.

Retrofire, at 1505, lasted for 180s and the ship was pulled to Earth. At 1526, at an altitude of 144 km, the three sections of Soyuz 38 separated and at 1531 the descent cabin entered the upper layers of the atmosphere. The crew experienced overloads of 4G while the external temperature topped 3,000°C.

At 1540 radio contact was reestablished and by 1550 the parachutes had unfurled. At a height of about 1m the retrorockets at the base of the descent cabin fired to slow the velocity to 3.7m/s. Soyuz 38 had made a soft landing some 175 km SE of Dzezkazgam at 1554 just 3 km from the designated target. It was one of the most accurate landings in the Soviet space programme.

Earth Observations Tasks

TROPICS 3: This programme, a natural extension of the earlier Tropics 1 and 2 mapping surveys from air and ground of Cuba's natural resources, took the mapping task into space. As the cosmonauts took photographs of Cuba with the MKF-6M multi-spectral camera teams in the air and on the ground gathered similar data. Specific sugar-producing areas of Cuba were mapped as were the island's insular shelf and other regions of geological interest. Natural resources investigations and environmental pollution were high on the list of specific studies.

BIOSPHERE - C: The visual and photographic recording of areas of natural interest were the aims of this open-ended experiment performed by Tamayo.

SPECTRUM: This experiment involved studies of Cuba with the Spektr-15 instrument to develop methods of determining the physical, chemical and biological characteristics of some agricultural and natural areas and the study of the sea water around Cuba by spectral means.

In addition the *CONTRAST, HORIZON, TERMINATOR* and **ATMOSPHERE** experiments were continued using photographic, spectral and polarisation filters, such as the VPA-1 filter, to determine the atmosphere's optical characteristics to help eliminate photographic distortions. The study of solar light by spectrometer and photography of the Sun at various altitudes over the horizon were used to determine these characteristics. As the Taimirs gathered the data the Dniepers

Mendez and Romanenko on a visit to Leningrad.

oriented the station.

Looking slightly weary, the cosmonauts were flown from the landing site to Dzezkazgan and then to Baikonur where, just 24 hours later, Aleksei Leonov told reporters that they were in excellent shape with all signs of stress and weariness gone. The cosmonauts were accorded several national and party honours from both countries. They were received in the Kremlin on 1 October. The Soyuz 38 descent cabin is to be presented to a Cuban museum.

Progress 11 In Flight

Although the Dniepers were scheduled to return home by mid-October much work still remained for them to do before they could pack their bags. To ensure that Salyut 6 could be re-used if necessary, or brought out of orbit without using the suspect ODU main propulsion system, the Soviets took the opportunity to dock another Progress cargo ship.

Progress 11 lifted off from Baikonur at 1510 on 28 September into an initial orbit of 193 x 279 km; period 88.8 minutes; incl. 51.6°. After a nominal 2 day rendezvous sequence the cargo ship docked with Salyut's aft docking unit at 1703 (30 September). The cargoes delivered were mostly food, regenerators for the life-support system, pieces of equipment and water. The cosmonauts began the unloading quickly and by 4 October all the cargoes had been unloaded and the loading up of the items of no further use began. On 8 October the SKDU of Progress 11 was used to trim the orbit of the three spacecraft complex.

Simultaneously with the unloading, the cosmonauts began their descent programme which would ensure they were ready for the readaptation to the Earth's gravity. The programme included regular exercises and time wearing the Chibis suit; regular taking of salt and water supplements to rectify the partial dehydration caused by weightless conditions, and blood sampling. They also cleaned the station, leaving it as they would wish to find it, and effected a few minor repairs. Generally they worked faster than scheduled which indicated to the FCC physicians their excellent health. The final large-scale experiment before deactivation of the equipment was one designed to test the structural stability of the complex and code-named *Amplituda*.

Descent To Earth

Early on 11 October the Dniepers were awoken to begin their preparations for the return. After breakfast the men packed the final items of scientific interest for return and, about 20 minutes before crossing into Soyuz 37, took some final pictures of the Earth. The cosmonauts had tested the Soyuz 37 SKDU the day before and all that remained once the lights had been switched off was to close the hatches and wait for the undocking signal.

At about 0630 the Salyut 6/Progress 11 and Soyuz 37 parted company. The cosmonauts had left Salyut as they had arrived, with a Progress cargo ship attached to the aft docking unit. The descent was normal following retrofire at about 0900. Throughout the descent the cosmonauts provided a running comentary. The touchdown, at 0950, was shown on TV some time later. The point of landing was a field some 180 km SE of Dzhezkazgan.

The recovery helicopters were soon at the scene and the physicians erected a tent for the medical examinations. Ryumin was first out of the cabin and surprised the doctors by walking unaided to the lounge chairs provided for them. The medical examinations showed that they had stood up well to the long flight of 185 days. The cosmonauts displayed a jaunty humour with the pressmen at the landing site and it was soon clear that Popov and Ryumin would readapt faster than any previous crew.

Returning to Baikonur the same day the cosmonauts looked happy and fit as they stepped from the aircraft. They were taken to the *Hotel Kosmanavt* and left to sleep in readiness for a long series of medical tests.

Readaptation to Earth's Gravity

Exactly 20 hours after landing, and following their first sleep back on Earth, the cosmonauts surprised the doctors by taking an unaided walk lasting 1,500 paces or just about ½ an hour. During the walk their pulse rate quickened by just 15 to 20 beats. The medics stated that this was the fastest that any crew had overcome the first acute stages of readaptation. The crew were then allowed to eat their first real food at the same cafe where they had dined before departing for the Salyut station on 9 April. The meal consisted of salad, yoghurt, ham, pickled cucumbers, Ukranian cabbage soup and bread given to them at the landing site.

Despite their good condition, the medics said that they did not intend shortening the Dniepers' period of post-flight tests. The cosmonauts' day was divided into 32 separate activities, or points, 20 of them related to medicine. Breakfast, for example, featured as point 10 on the schedule. The unplanned walk was entered as a new point called "dosed loading in the open air" The days lasted for 12 hours with some free time at the end of them.

The cosmonauts requested a daily 30 minute chat with journalists inbetween medicals and exercises. By 15 October the men were able to play tennis. Talking to a reporter during one of his walks Ryumin said that in his opinion the only real problem with the execution of a year-long flight in space was the ability of FCC to keep the cosmonauts active and interested. With a meaningful and varied work routine a 12 month flight was possible, Ryumin said; "indeed, if it was needed to prove we could go to Mars then Leonid (Popov) and I would volunteer right now."

In addition to the usual references, listed in part 1 of this series, the writer would like to express grateful thanks for information supplied by the staff of the Cuban Embassy, London. The report of the flight of the first Cuban cosmonaut was compiled from information contained in the daily TASS reports and the Cuban party newspaper 'Granma'.

In the next part of this report the results of the medical and other experiments will be discussed.

NEW WEATHER SATELLITE

NASA's launch of GOES 5 Geostationary Operational Environmental Satellite 5) on 22 May is another step in updating the system of world-wide weather satellites in equatorial geosynchronous orbits.

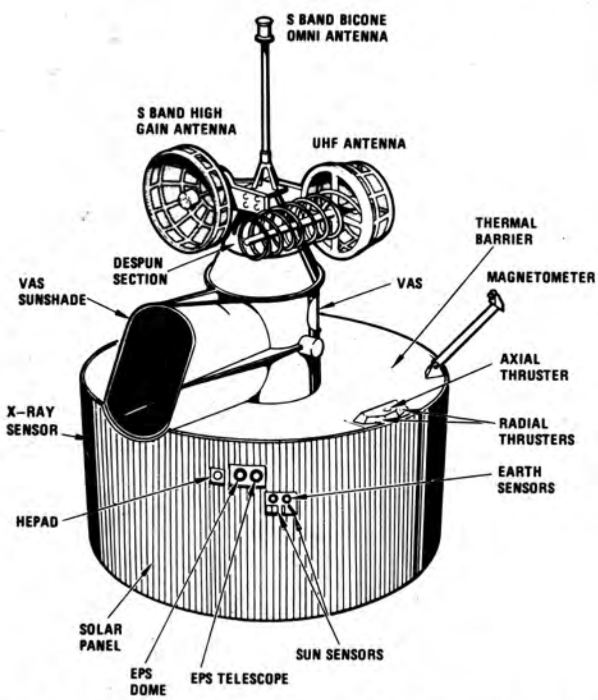
The Global Atmospheric Research Programme of 1978-79 included the use of five similar vehicles - three GOES, the European Meteosat 1 and the Japanese GMS (the Soviets failed to launch their contribution in time) - to provide comprehensive coverage of the globe. The system provided almost real-time observations of severe weather patterns, thus allowing warnings to be raised in time for threatened areas, and collected vast amounts of data on temperature, humidity, rainfall, etc. from remote unmanned ground and ocean stations.

The main instrument of these earlier GOES (also known as the SMS or Synchronous Meteorological Satellites) was the Visible and Infra-Red Spin-Scan Radiometer (VISSR). Reflected sunlight, or radiated heat during the night, shows up the differences between water, land and clouds. The advanced version of VISSR was first launched with GOES 4 last September and also allows temperature and water vapour profiles of the atmosphere to be made. The latter is particularly important because water vapour is thought to be vital for absorbing the Sun's heat in the atmosphere and driving our weather processes.

GOES 5 will settle down at 85° west longtitude to cover North and South America, plus some of the Atlantic.

GOES 4 is performing similar services for the western half of the United States and Canada and much of the eastern Pacific Ocean from its position at 135° west above the equator.

NOAA, the National Oceanic and Atmospheric Administration, has maintained operational geostationary spacecraft at these locations for the past six years as part of its responsibility to observe and monitor the Earth's weather and some of its resources, as well as some solar activity. The Commerce Department agency also operates a two-spacecraft polar-orbiting satellite system (using Tiros) which provides imagery and data of the entire Earth's surface.



GOES 5, launched 22 May, is the first of three metsats to carry the advanced radiometer instrument (referred to as VISSR in the text but here labelled as VAS).

Hughes Aircraft Company built both the spacecraft and the main instrument, as well as the satellite's Data Collection System instrumentation and its Telemetry, Tracking and Command Sub-system. The Data Collection System collects and relays environmental data back to Earth from more than 1,500 existing remote platforms on land, at sea and carried aloft by balloons and aircraft, while the telemetry subsystem performs a variety of communications functions.

Also included in the spacecraft's instrumentation package is a Space Environmental Monitor which obtains measurements of solar activity, detects solar flares and measures solar wind intensity and the strength and direction of the Earth's magnetic field.

GOES 5 coast about $20 million, and its launch by the 154th Delta vehicle cost an additional $16 million.

Once checked out by NASA, the new spacecraft will be under the control of NOAA's Natonal Earth Satellite Service, which will make the imagery and digital data available to users world-wide through its existing distribution network.

The sounding data from the main instrument is not yet available operationally. NOAA is working with NASA to determine how the atmospheric temperature and moisture profiles could be provided to operational users such as the US National Weather Service in the late 1980's.

'SUPER SHUTTLES' UNDER STUDY

'Super Shuttles' which almost match the heavyweight capability of the Saturn V Moon rockets are being studied, writes Gerald L. Borrowman.

The Marshall Space Flight Center has issued a $596,867 contract to Martin Marietta Aerospace Corporation in New Orleans, to study options for upgrading the Shuttle.

The Shuttle, intended as a reusable spaceplane, has a 15×60 ft bay designed to carry cargoes of up to 65,000 lb into a low easterly orbit when launched from the Kennedy Space Center. But larger cargoes are possible, depending on what mission requirements NASA see for the 1990's.

In the first phase of the 18-month contract, Martin Marietta will study such mission requirements and develop basic designs for four Shuttle derivatives. Detailed analysis of technology required for more promising concepts will be conducted in the second phase.

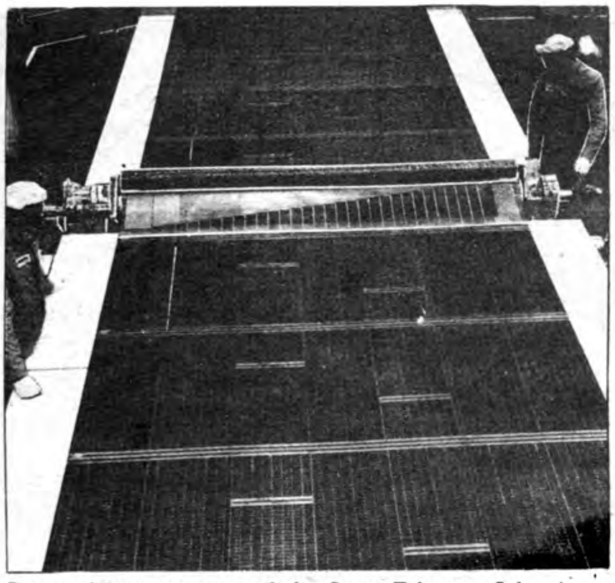
NASA considers this work to be "technology identification" rather than the start of a new vehicle design.

The four basic types of Shuttle variants are:

1. Placing the main engines in a recoverable module below the external tanks would take 15,000 lb of cargo away, but would make the cargo hold 75 ft long and allow return cargoes to be heavier.
2. Liquid rocket boosters using cousins of the main engines would be more powerful than solid boosters and raise the total cargo to 100,000 lb.
3. The Shuttle orbiter can be replaced with a one-way cargo cannister about the size of the Skylab space station and weighing 150,000 lb. The engines would be in a recoverable module under the can.
4. Finally, an all-cargo version with liquid rocket boosters to lift total payload of 200,000 lb into low Earth orbit.

Costs would also be lower. Earlier studies projected the cost per pound of cargo to be as low as 23 per cent that of the regular Shuttle, while the cost per mission drops to about 80 per cent.

Several improvements are already planned or are being considered at Marshall: squeezing more power out of the main engines and solid rocket boosters, shaving weight off the external tank and boosters, using lightweight booster casings, and using the Titan 3 first stage under the tank to provide an



Recent deployment tests of the Space Telescope Solar Array deployment mechanism by British Aerospace have confirmed its success in ground operation. Space Telescope is to be positioned in orbit by Shuttle in 1985 for a mission life of 15 years. British Aerospace are under contract to the European Space Agency to develop the solar arrays which are the sole source of power for the telescope. The photograph shows one 'wing' of two solar array blankets, half of the total solar array area which provide power during its five year initial life in orbit. Both blankets are contained on a single drum with Kapton cushioning between to prevent the solar cell surfaces touching each other. These unique man-rated arrays will measure 356 sq. ft. (33 sq. metres) overall and their 48,760 solar cells will initially provide 5 Kw at 34 volts. Some 420 flat on-blanket diodes provide protection against partial shadowing by the Space Telescope appendages.

extra boost. All told, these may add as much as 54,000 lb to the basic Shuttle's cargo, bringing it up to 119,000 lb.

Added to the Super Shuttle above, they might ultimately increase the maximum cargo to as much as 245,000 lb, almost matching the heavyweight record of the Saturn V Moon-rocket.

NASA has no firm plans for cargo more massive than 65,000 lb requiring assembly in orbit, although satellite power stations, large space bases and even manned planetary missions might require it. However, NASA has found that the capability can generate the need. Critics of the Shuttle programme claimed in the early 1970's that there never would be enough payloads to justify such a vehicle. Now we find that delays have forced NASA to build more expendable launchers to satisfy customers' demands.

STS-1 ENGINE PERFORMANCE

"Flawless," was the initial report from Robert E. Lindstrom, Shuttle Projects Office manager at NASA's Marshall Space Flight Center, on the performance of the Shuttle's three main engines, External Tank and Solid Rocket Boosters (SRB) during the ascent phase of the Shuttle's maiden flight on 12 April.

"Everything looks great, and we are ready to go (with STS-2)," said Lindstrom following several days of preliminary flight data analysis by Marshall Center engineers and Shuttle project managers. "We have no anomalies in the boost phase performance of our systems, and we see nothing that would require and design changes or modifications for the next flight," he added.

"We have looked at the engine data and it looks exceptional. The engines were extremely close to predicted performance," said Lindstrom. "The External Tank and the SRBs performed within specification with the proper performance in all subsystems."

The only problems noted came after the successful boost phase of the flight. There was a problem with the valve on the tank which is supposed to cause the tank to tumble after it is jettisoned. SRB water impact loads were slightly greater than expected, which resulted in some damage to the booster's aft skirts, and one parachute on each of the boosters was lost after the water landing, when their flotation systems apparently malfunctioned. Some damage due to heating also occurred during reentry.

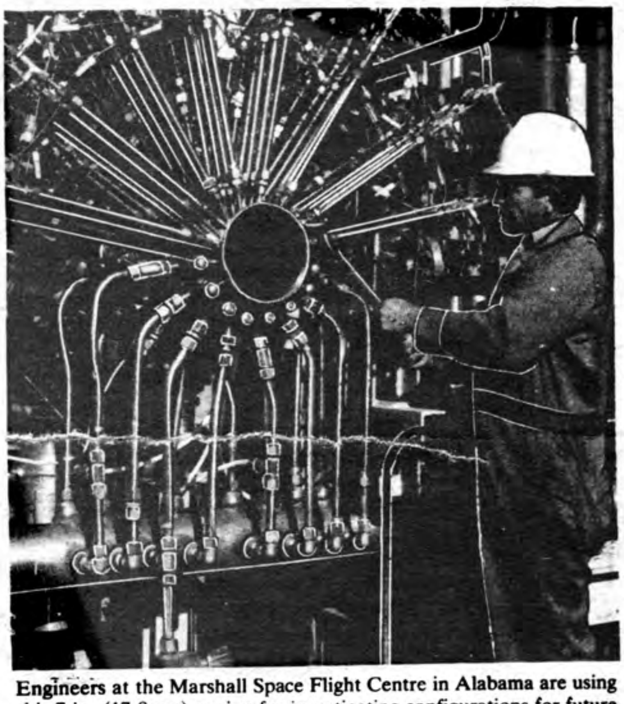
The SRB problems affect the reuseability and refurbishment of the SRB systems, and MSFC engineers will address these issues in the coming months.

ET-2, the External Tank for the second Shuttle mission, left Marshall on 17 April for Canaveral following propellant loading tests at the National Space Technology Laboratories in Mississippi.

EINSTEIN OBSERVATORYCOMPLETES MISSION

NASA's second High Energy Astronomy Observatory (HEAO 2) has expended its control gas supply, completing its flight mission. With two years and five months of operations, HEAO2, like HEAO 1, performed for more than twice as long as its design called for - a feat expected to be equaled by the third observatory which is still in operation.

HEAO 2 was launched on 13 November 1978 carrying the world's largest focusing X-ray telescope and an array of imaging and analysing astronomy instruments. During its



Engineers at the Marshall Space Flight Centre in Alabama are using this 7 in. (17.8 cm) engine for investigating configurations for future engines, possibly for heavy-lift versions of the Shuttle. Present thinking has been to add extending skirts to engines to give higher efficiency over the entire flight path. The problem there, though, is that a skirt may be cumbersome and difficult to control under actual flight conditions. Marshall have therefore been using this 40,000 lbf engine to test a dual throat burning system to achieve the same increased efficiency. The hope is that two throats - one large and one small - would be simpler to build and control. The larger one would be used at launch, with the propellant flow switching to the smaller one later in the flight.

extra-long lifetime, it performed thousands of studies of X-ray stars, supernova remnants, galaxies and quasars.

HEAO 1 was launched on 12 August 1977 to make an all-sky survey in X-rays to pin-point likely targets for subsequent missions. HEAO 3 went into orbit on 20 September 1979 and is still operating. Europes Exosat craft will perform the same sort of mission when it goes up next year and the Gamma Ray Observatory will look at higher energy radiation later this decade.

PAYLOAD FOR SECOND SHUTTLE

When *Columbia* makes her second flight into orbit, this time piloted by Joe Engle and Dick Truly, she will carry the first load of experiments in her cargo bay. STS-1 was mainly a 'get-up-there-and-get-back-down-safely' mission and carried only monitoring equipment to record data on the Orbiter's condition and performance.

The payload for STS-1 is OSTA-1, named after NASA's Office of Space and Terrestrial Applications who provides most of the seven experiments. It is designed to demonstrate the Shuttle's capability as an operational space platform for scientific and applications research with the experiments primarily looking at remote sensing of land resources, atmospheric phenomena and ocean conditions.

These include an imaging radar (Shuttle Imaging Radar, or SIR-A) to test advanced techniques for mapping geological structures important in oil and gas exploration; a multispectral infrared radiometer (SMIRR) to measure the solar reflectance of mineral-bearing rock formations; a feature recognition system (Feature Identification and Location Experiment, or FILE) designed to discriminate between water, bare ground, vegetation, snow or clouds and thus control sensors to collect only desired data; an air pollution measurement experiment (measurement of air pollution from satellites , or MAPS) designed to measure the distribution of carbon monoxide in the middle and upper troposphere (12-18 km or 7.5-11 miles altitude); an ocean colour scanner (Ocean Color Experiment, or OCE) to map algae concentrations which may indicate feeding areas for schools of fish or pinpoint possible pollution problems; a night and day optical survey of lightning storms (NOSL); and a biological engineering experiment (Heflex Bioengineering Test, or HBT) to determine the relationship between plant growth and moisture content in the near-weightlessness of space.

An engineering model of a Spacelab pallet, a 3 m (10 ft) long U-shaped structure mounted in the cargo bay, carries most of the experiments. The pallet is equipped with subsystems to provide power, command, data and thermal interfaces for the instruments.

The imaging radar, radiometer, feature recognition, pollution measurement and ocean scanner experiments are mounted on the pallet; the lightning and biological engineering experiments are mounted in the Shuttle's crew compartment.

STS-2 will be launched from the Kennedy Space Center into a 280 km (174 mi) circular orbit with an inclination of 40.3 degrees. For approximately 3.5 days (88 hours) of the four-day mission, the Shuttle will be in an Earth-viewing orientation where the payload bay faces the Earth on a line perpendicular to the surface. During this period, the instruments will be operated and data collected.

The flight operations of OSTA-1 will be controlled from the Johnson Space Center Payload Operation Control Center (POCC) in Houston. The air pollution and feature recognition experiments operate continuously for the whole mission with the imaging radar, radiometer and ocean experiments taking data over preselected sites. The lightning experiment is a 'target of opportunity' instrument experiment housekeeping data is available in the Payload Operation Control Center to monitor the status an health of the instruments, and the Payload can be commanded from the control centre, or by the astronaut crew *via* the Shuttle's general purpose computer.

Since most of the Shuttle data transmission capability will be taken up with Shuttle status data this flight all of the OSTA-1 scientific data will be recorded on borad on tape and film.

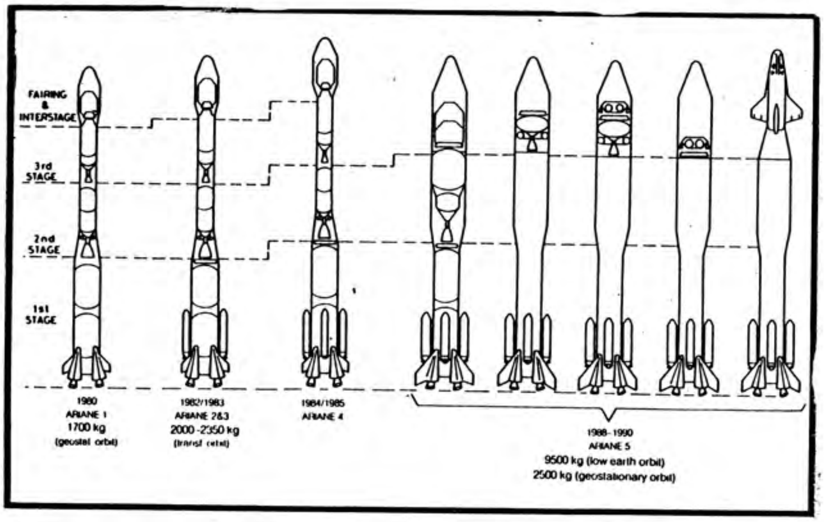
ARIANE TO THE PLANETS

A study by the European Space Operation Centre's Mission Analysis Office has shown that the Ariane III and IV launcher versions, plus a fourth stage, can handle useful payloads to the planets, comets and asteroids.

Ariane IV should be available in the middle of this decade and with a fourth stage it could put 1649 kg into orbit around the Moon. Since Europe is interested in POLO (Polar Orbiting Lunar Observatory) for making a complete global survey of the Moon's physical and chemical properties this is an important result.

The same launcher combination could send 1950 kg towards Mars where it could slip a vehicle into a circular equatorial orbit near Phobos or Deimos (masses after retromanoeuvres 721 and 672 kg, respectively). Ariane III could handle about half of these masses. Smaller velocity changes could then result in a Mars-moon orbiter or lander.

Direct launches to Jupiter and Saturn require higher energies and only fly-by probes are really feasible for Ariane this decade. Even then they are under 400 and 300 kg for Jupiter and Saturn, respectively. However, a 1000 kg craft



A projected development sequence for Ariane. Up to Ariane IV will be built but Ariane V is by no means certain. A two-stage version of Ariane V has been proposed as a launcher for the 'Hermes' mini-shuttle.

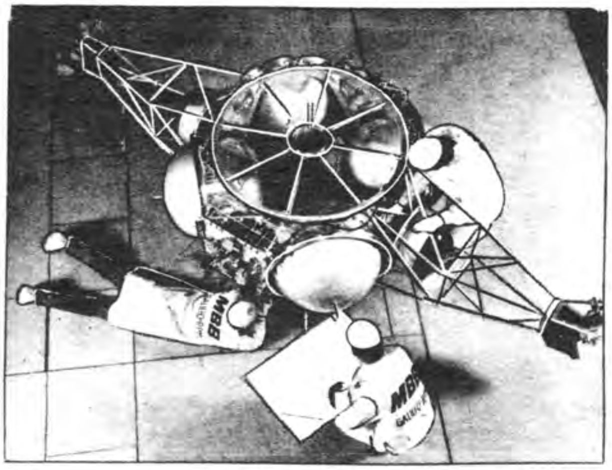
could be put into orbit about Venus.

A multiple-asteroid mission (Asterex) is being studied by ESA at present for this decade. One quoted example is a five-asteroid fly-by with a vehicle weighing 970 kg before the first encounter.

Comets, of course, will be coming under close scrutiny for the first time when Halley is intercepted in 1986. ESA's Giotto probe will weigh about 750 kg and carry 50 kg of experiments but, by comparison, a 1987 mission to Comet Borelly by Ariane IV/fourth stage could see a 1500 kg probe being used.

GALILEO TAKES SHAPE

In its work on the propulsion module for the Galileo Jupiter Orbiter, MBB reached two important milestones on schedule at the end of 1980. The Critical Design Review of the module was successfully completed, and the full-scale configuration model was delivered to Jet Propulsion Laboratories in



California. This model is used by JPL to test the interface between the propulsion module and the rest of the Galileo system. The propulsion module now delivered is the first of three systems which are to be built by MBB and supplied to the United States in the course of the programme.

The design for the Galileo propulsion module has been checked out in three stages since July 1980, by the contracting authority DFVLR-BPT and by representatives of JPL, the West German Federal Ministry of Research and Technology and NASA. The design was accepted and the go-ahead for construction of the flight model given at the final meeting of the review commission at Ottobrunn under the chairmanship of Dr. Pfeiffer of the DFVLR.

Since development of the propulsion module for Galileo's Jupiter mission first began, JPL's increasingly stringent requirements and changes in NASA's project plans have repeatedly forced MBB to make complicated and costly modifications to the design. These concern primarily three areas:

- Development and construction of the structure and tanks had to be changed several times.
- The 400 N and 10 N propulsion units adapted from the Symphonie comsat were developed further to meet the very high requirements for the Galileo mission. A new record was set in July 1980 when a 10 N unit achieved a trouble-free burning time of 14 seconds under vacuum conditions.
- New valves and valve assemblies had to be developed and produced, while the reliability requirements for the mission and the safety requirements for the Shuttle launch system made it necessary to provide a very complex feed system in the propulsion module.

The launch of Galileo is currently scheduled for some time durng 1985. It will be NASA's major planetary probe of this decade.

CHANGES IN VENUS' ATMOSPHERIC WINDS

Significant discoveries concerning the pattern of atmospheric changes on Venus have been made based on two year's worth of Pioneer observations. The discoveries indicate a long term period of change for both the planet's wind patterns and for the existence of a haze layer above the cloud tops.

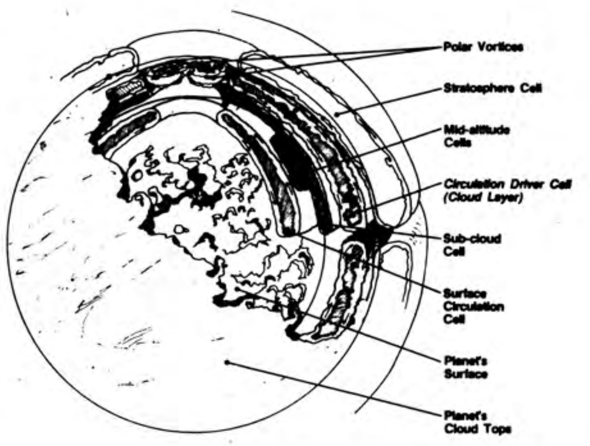
The Pioneer orbiter has taken about 1000 pictures of Venus' clouds and extensive measurements of the particles composing those clouds. The most noteworthy of the discoveries is that Venus' planet-wide wind patterns change dramatically over a period of several years. two patterns have been discerned - a mid-latitude jet stream pattern and a cloud and wind pattern which acts like a solid body.

A second discovery shows that the high-altitude haze layer which completely envelopes Venus' clouds appears and disappears over several-year periods. This haze is a 'smog layer' extending above the main cloud region by about 30 km (18 miles). (On Earth this height would be well into our stratosphere).

The Pioneer Venus orbiter is expected to return pictures and other data until 1985; the orbiter reached Venus in December 1978, and the four Pioneer probe craft entered the atmosphere at the same time.

The two new discoveries of a multi-year change in the pattern of global winds, and similar changes in the planet-wrapping haze layer could help to explain the major remaining mystery of Venus' atmosphere; why, on a planet which has almost no axial rotation, do the upper level winds circle the planet at tremendous speeds of 360 km/hr (225 mph). These winds completely cover the planet, blowing at virtually every latitude from equator to pole. Their speeds can be determined from the speeds at which the clouds, carried by the winds, travel around the planet. Wind speed measurements from top to bottom of the atmosphere by the four Pioneer probe craft show that these high-speed, cloud-level winds are coupled to lower altitude winds, which also have very high speeds.

The 360 km/hr (225 mph) cloud level winds blow around the planet at an altitude of 65 km (40 mi). Wind speeds then range



Venus' atmospheric circulation. At cloud top level, the atmosphere circles the planet once every four days, while closer to the surface it travels much more slowly. The atmosphere is heated at the equator by the Sun, slowly moving towards the poles as well as journeying around the globe. It reaches the poles, descends towards the surface and then returns to the equator to begin the cycle again.

down to 192 km/hr (120 mph) at 50 km (30 mi) and to a still-very-high 80 km/hr (50 mph) at 20 km (12 mi) altitude.

The mass of the moving atmosphere constituting these high-speed winds is several times that of our entire atmosphere. It represents about a quarter of Venus' atmosphere which is about 100 times denser than Earth's. Despite the scale of these high-speed, upper level winds, well over half of Venus' tremendously dense atmosphere, near the planet's surface, is almost stagnant. From the surface up to 10 km (6 mi), wind speeds are only about 3 to 18 km/hr (2 to 11 mph).

In a general way, the high-speed winds can now be explained as due to the transfer of momentum from Venus' slow-moving, massive lower atmosphere to higher altitudes where the atmosphere is less massive, so that the same momentum results in a much higher velocity. These new discoveries of long-term changes in global wind patterns and an enormous disappearing haze envelope could help scientists to further define the 'driver' for the planet's high-speed winds. Any future general atmosphere circulation model for Venus will have to account for these long-term changes in wind and cloud patterns.

Details of these and other major findings from the two-year analysis of the Venus cloud and polarimetry data include:

- It is now clear that the high-speed movements of Venus' clouds around the planet are not caused by wave motions in the atmosphere, as was thought possible, but are real winds (although there are some wave motions as well). These planet-circling winds, which carry along the clouds, are the same ones which were measured by the four Pioneer Venus probe craft as they descended to Venus' surface in December 1978. These winds blow in an east to west direction, circling the planet once every four days at speeds near the equator of 360 km/hr (225 mph), and near the poles (at around 70 degrees latitude) of 160 km/hr (100 mph). The Pioneer cloud pictures show the region of Venus' main cloud deck at altitudes between 60 and 65 km (37 and 40 mi) above the planet's surface.

- The global pattern of these planet-circling, cloud-level winds appears to change periodically. For the past two years of Pioneer observations. Venus' clouds and cloud-level winds have been exhibiting 'solid body' rotation. That is, they move around Venus as though they were made up of one solid, planet-encasing body. This pattern of motion, of course, means wind speeds are much higher at the equator than at the poles.

- Measurements of Venus' cloud level winds show that, in addition to circling the planet, they also blow toward the poles at speeds of around 25 km/hr (15 mph). These equator-to-pole winds (also seen by the four Pioneer probes at lower altitudes) carry heat from the Sun, absorbed near the Venus equator, to the poles. The speeds of these winds agree with the wind measurements by the four Pioneer probes. This indicates that the cloud-level winds are the upper limb of an equator-to-pole Hadley cell circulation loop, which carries Venus' equatorial heat poleward.

- The so-called global 'Y' pattern of Venus clouds with the tail of the 'Y' extending eastward around the planet, and the arms westward, appears at times, but is not typical. The 'Y' was first seen in ground observations.

  Sometimes the 'Y', which occasionally extends two-thirds of the way around the planet, disappears completely. At other times, it is so changed that it forms a 'C' or other shape. In general the planet shows a whole range of global cloud patterns in addition to the 'Y'.

- In addition to its well-known veil of clouds, two years of Pioneer polarimetry measurements show that Venus is currently enveloped in an 18-mile-thick blanket of high-altitude haze. The haze is present everywhere, but has about three times more particles per unit volume at the poles than the equator. At the poles, the haze is so thick that it obscures the base clouds beneath it. This haze of tiny sulphuric acid droplets is the 'sealer' of Venus' greenhouse effect, holding additional heat beyond that which would be trapped by the clouds and atmosphere alone. The planet's 482 °C (900 °F) surface temperature would be somewhat lower without the haze. Furthermore, inclusion of haze effects makes the Venus heat radiation models developed by scientists match the cloud top atmosphere structure observed by the Pioneer Venus instruments.

Venus' main clouds consist of sulphuric acid particles two microns in diameter, while in the haze layer the particles are smaller, only a quarter of that size.

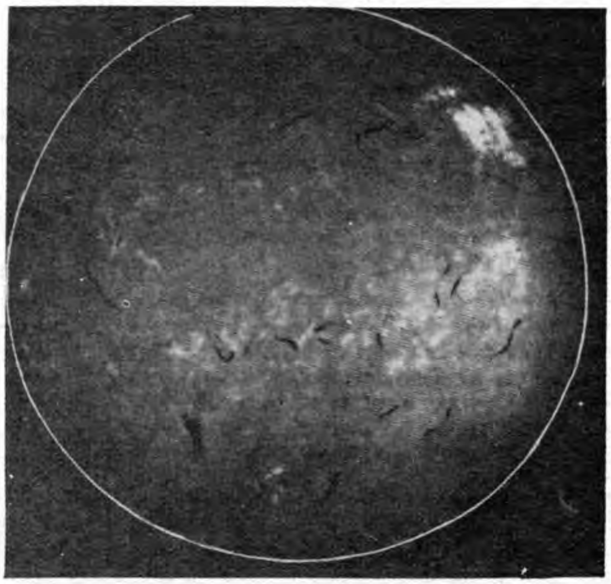
Over the next five years of the Pioneer Venus orbiter's extended mission (through to the end of 1985), the project investigators will be watching the clouds for changes. They will look for changes in the global circulation pattern such as the one which occured in the five years separating the Pioneer and Mariner 10 missions (1974-1979). Determining such factors as the rapidty of the change and the frequency of its occurrence should lead to further understanding of the Venusian high-speed winds.

MAPPING SATELLITE

Itek Corporation has recently completed a U. S. Geological Survey contract for the conceptual design of the Mapsat Earth resources satellites.

The company's Optical Systems Division was the prime contractor in a combined effort with TRW to determine the feasibility of an advanced solid state, multispectral stereo spacecraft. Mapsat is expected to be a strong candidate to succeed NASA's Landsat experimental satellites which have ben mapping the Earth from space since 1972.

Scheduled for a polar orbit in the late 1980's, could provide immediate, three-dimensional, high-resolution images of the land and shallow seas in either black and white or colour during a seven to ten year period. The actual mapping quality of the operational electro-optical land-observing system would provide map scales at 1:50,000 and information for oil and gas exploration.



A major solar flare - one of the largest for 10 years - is seen at top right in this picture taken by NASA scientists.

This quartz mesh is a candidate for using as the reflector surface in giant space antennae of the future.

Lockheed

GERMANY'S SHUTTLE PAYLOADS

NASA's Acting Administrator, Dr Lovelace, and the State Secretary for the West German Ministry for Research and Technology have signed a Memorandum of Understanding which puts Germany's Shuttle requirements on a more formal footing.

West Germany has already paid 'earnest money' to NASA for two reimbursable Spacelab missions. The first (D-1) will be for materials processing and life sciences experiments and the second (D-4) is currently planned for astrophysics experiments. Current plans also called for a German X-ray satellite (Rosat) to be launched by the Shuttle in 1986, although no specific launch date has been reserved. Private and scientific organisations in Germany have also reserved a total of 25 small Self-Contained Payloads for eventual flight on the Shuttle on a space-available basis.

NEW EXPLORER SATELLITES

Two further satellites in the extensive Explorer Series (beginning with Explorer 1 in January 1958) are due to be launched by Delta 3913 from the Western Space and Missile Center, Lompoc, California during 31 July.

The mission of Dynamics Explorer A and B will be to explore the boundary region between the Earth and space which affects the atmosphere, auroral displays, radio transmissions and, perhaps, climate and weather.

Solar radiation and the solar wind have a dynamic impact on the near-Earth environment, affecting the state of the atmosphere, ionosphere, magnetosphere and the more familiar phenomena (weather, auroral displays and radio disturbances). Previous satellites such as the Atmospheric Explorers have provided new information on solar radiation upon the lower thermosphere and upper atmosphere. The ISEE (International Sun-Earth Explorer) programme has provided new information on interactions between the solar wind and the Earth's magnetic field; however, adequate knowledge does not exist regarding interactions between the two regions.

The Dynamic Explorer programme will extend our knowledge of the strong interaction processes coupling the hot, tenuous, convecting plasmas of the magnetosphere and the cooler, denser plasmas and gases co-rotating in Earth's ionosphere, upper atmosphere and plasmasphere. To accomplish this, the project will provide a central data processing and analysis system so that each investigator on the science team can display geophysical data from all of the spacecraft instruments.

In their polar, complanar orbits, one satellite (DE-B) will have a perigee low enough (305 km or 190 miles) to allow it to make neutral composition, temperature and wind measurements. Its apogee, on the other hand, will be high enough (1,300 km or 808 mi) to give it a lifetime greater than 18 months, at the same time allowing measurements above the interactive regions for superthermal ions and plasma flow measurements of the magnetospheric field lines.

The second spacecraft (DE-A) will be placed into a highly elliptical orbit with an apogee of 24,875 km (15,457 mi) for global auroral imaging, wave measurements in the middle of the magnetosphere and traversals of auroral field lines at several Earth radii.

The DE-B (low mission) has six 3 cm (1.2 inch) diameter flexible stem antennae 10 m (33 ft) long and a single rigid boom 6 m (20 ft) long to collect data for the scientific instruments. The solar cell arrays mounted on the 136 cm (53.5 inch) diameter spacecraft body will supply power for the scientific instruments or storage in nickel-cadmium batteries.

DE-A is spin stabilized its pitch (or spin) axis having a spin rate of 10 rpm. DE-B is three axis stabilized with its pitch axis continually pointing towards the Earth. Both spacecraft are designed to minimise the unbalancing torques created by atmospheric drag encountered in the tenuous atmosphere at orbital altitudes.

The Explorer programme has included a number of atmospheric investigation satellites. The atmospheric Explorer subseries began with Explorer 17 in 1963, continuing with Explorer 32 (AE-B) in 1966. Explorer 51 (AE-C) was the first of the second generation satellites; by using a highly elliptical orbit it could dip down as far as 77 miles altitude to sample the lower reaches of the atmosphere usually inaccessible to satellites. Its propulsion unit was then used to prevent early orbital decay. Explorers 54 (AE-D) and 55 (AE-E), launched in October and November 1975, respectively, were essentially identical except that AE-E carried instruments to measure ozone in the upper atmosphere. AE-D pursued a similar programme as AE—C but in the polar regions where its predecessor could not reach.

The four Explorer balloon satellites (9, 19, 24 and 39) provided information on air densities in different orbits over long periods.

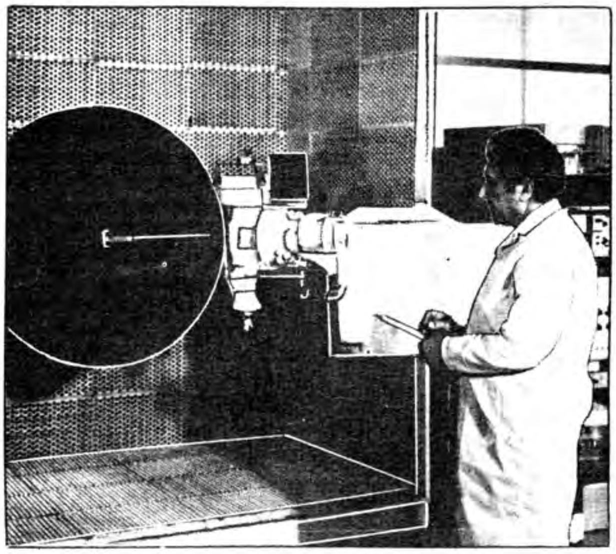
ARTISTS RECORD COLUMBIA'S FLIGHT

A tradition nearly as old as the space programme itself continued when artists recorded the events at Kennedy Space Center during the first flight of the Space Shuttle *Columbia* for NASA.

For more than 18 years, NASA's art programme has commissioned artists to render their impressions of key events in the space programme. The artist donates time and talent in return for an honorarium to cover expenses.

The purpose of the agency's art programme is to collect an archival history of the exploration of space. Artists have been present at Cape Canaveral as astronauts suited up for their flights and were launched into space, and they have been aboard recovery ships when the astronauts returned to Earth. They have also flown simulators to experience at least a taste of what it is like to fly in space.

Participating artists have ranged from traditionalists such as Peter Hurd and James Wyeth, to modernists such as Robert



The Integrated Radar and Communications Subsystem (IRCS) aboard Space Shuttles will place the crews in voice, closed circuit TV or high speed data contact with a ground station at White Sands N.M., *via* one of two NASA tracking and Data Relay Satellites geosynchronously stationed over the Atlantic and Pacific. The system will also be used independent of ground assistance to locate space hardware in low orbit for repair, maintenance or retrieval. Four IRCs will be operational on Space Shuttles in 1983. The antenna dish of a prototype model is shown here during tests.

Rauschenberg and Lamar Dodd. The art produced varies from subjects closely seen and sharply delineated to those only sensed or imagined by the artist. There is considerable precedent for artists to record historic events such as a space flight. Artists have long recorded important events in American history, including the settlement of the West, the Civil War and World Wars I and II.

The paintings, drawings and other works of art produced under the programme become the property of NASA but they are frequently loaned to museums or other organisations for display. Many are on display in the Smithsonian Institution's National Air and Space Museum in Washington, D.C. Others grace the walls at NASA's Washington headquarters.

If level of interest is any guide, artists will continue to contribute to a visual history of space exploration; many have already written to NASA requesting to fly aboard a future Space Shuttle mission should the opportunity arise.

WATERHOLE: THE BIG SURPRISE

Like all scientists, those at the Herzberg Institute of Canada's National Research Council are trained not to draw conclusions from a single experiment, but the results of their Waterhole rocket shot in April of 1980 are causing some excitement, writes Gerald L. Borrowman. Based on independent readings from rocket-borne and ground-based instruments, a temporary intervention in the high-atmosphere processes creating the Northern Lights has exceeded all expectations.

The Waterhole project involved seeding the Earth's ionosphere with water molecules at an altitude of about 300 km over as wide an area as possible. The seeding, done suddenly with a high-explosive rocket warhead, caused a dimming of the aurora by 50 per cent throughout the area scanned by the instruments - perhaps across the entire sky. Perturbations in particle and magnetic flux were also noted.

If these initial results are indeed borne out in future rocket experiments, then the National Research Council researchers have somehow influenced the high-speed particles that induce **the aurora at their distant source in deep space high above the Earth's north pole. A way may now be open for the investigators to dim and brighten the Northern Lights, or even turn them on and off, at will.**

GAMMA RAY OBSERVATORY

The scientific instruments which will fly aboard the Gamma Ray Observatory, now scheduled for a 1988 Shuttle launch, have been selected by NASA's Office of Space Science.

Those selected are:

1. Transient Event Monitor to detect the short, intense bursts of gamma rays which are currently of unknown origin, and pinpoint them with sufficient accuracy to determine their distribution in the Galaxy.

2. High Energy Gamma Ray Telescope to measure the energy spectrum and arrival directions of the highest energy gamma rays that can be observed.

3. Imaging Compton Telescope to provide gamma ray maps of the celestial sphere at medium energies.

4. Low Energy Gamma Ray Spectrometer to search the lowest energy gamma ray region for spectral features, such as evidence for nucleosynthesis in supernovae.

Studies of gamma ray sources and gamma ray production are at the very heart of understanding the dynamics and evolution of stars, galaxies and the Universe. Gamma rays are produced in the most powerful processes in the Universe and their high energies qualify them as the most direct probe we have of these processes. A single photon of visible light energy has the equivalent of one electron volt of energy (1 eV), while the gamma rays measured by the Gamma Ray Observatory will begin at about one hundred thousand electron volts energy (100keV) and continue up to several hundred million electron volts energy (100 MeV, or more).

The predecessor spacecraft to the Gamma Ray Observatory are the High Energy Astronomy Observatory-3, which looked at high energy X-rays and low energy gamma rays, and the Small Astronomy Satellite-2 and COS-B (a European satellite), which looked at high energy gamma rays.

The Gamma Ray Observatory will be placed into a 400 km (249 mile) high, 28.5 degree-inclined cicular orbit with, hopefully, a useful lifetime of two years. It will be one of the largest observatory satellites ever placed into orbit, weighing about 10,432 kg (23,000 pounds) and 7.6 m (25 ft) long and 3.8 m (12.5 ft) in diameter.

SHUTTLE BOOSTERS

A $13.8 million contract has been awarded for work in support of the Shuttle at Vandenberg Air Force Base, California. The contract, awarded to United Space Boosters, is for first phase development of a ground support system for the Space Transportation System.

United Space Boosters currently has a contract with NASA for assembly, integration, launch and retrieval of the Shuttle's two solid rocket boosters. The unit operates two specially designed ships, the *UTC Liberty* and *UTC Freedom*, for this purpose. It successfully retrieved the two boosters from the Atlantic after the launch of *Columbia*.

The boosters supply most of the thrust for the Shuttle during the first two minutes of flight. Then they are parachuted into the sea for retrieval. United Space Boosters tows them to shore for refurbishment and reuse.

The new contract with the Air Force calls for Space Boosters to prepare operations and maintenance instructions for assembly, test, launch, recovery and refurbishment of the solid rocket booster system for Air Force operations at Vandenberg. The Air Force is expected to begin launching the Shuttle from Vandenberg in 1984-1985.

TWO SPACE EXHIBITIONS

A Soviet space exhibition spanning a wide range of their space achievements was opened in Zagreb, Yugoslavia in September 1980 under the auspices of the USSR Academy of Sciences with the theme 'Satellites in the Service of Man', writes Natko Bjelcić.

Perhaps the most impressive display was an animated model showing a Vostok launch. The rocket is brought to the pad on its rail transporter, raised to the vertical and fuelled ready for lift-off. The 15 minute sequence ends with the Vostok rising off the pad to the accompaniment of a recording of Gagarin's words at the start of his own flight.

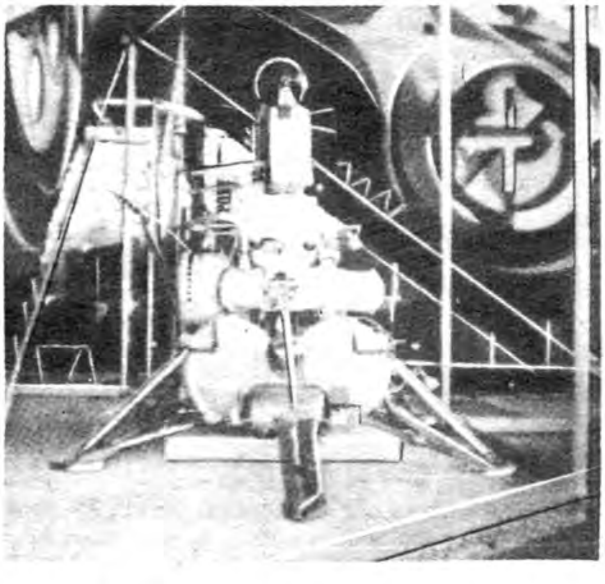
Unmanned probes and satellites were well to the fore. Another animation shows the Lunokhod 2 rover leaving its Luna 17 carrier to begin its 37 km (23 mi) journey across the lunar surface in 1973. A full-scale mockup of the rover is also included. Its predecessor, Luna 16, is represented by a half-scale model, showing the return capsule which brought back 100 gr (4 ounces) of soil samples in September 1970.

Models of two interplanetary probes, Venus 3 (struck our sister planet in March 1966) and Mars 3 (made the first TV transmission from the surface of the Red Planet) were also included.

. . . and in London

An exhibition of a different kind opened in London on 9 April in time to commemorate the 20th anniversary of Gagarin's flight, writes Andrew Wilson. Some 200 large photographs on the theme of 'Twenty Years in Space' were displayed covering the whole range of Soviet manned spaceflight from Gagarin to the Interkosmos crews of Salyut 6. A smaller number illustrated unmanned exploration.

The exhibition was opened by the Soviet Ambassador, Viktor Popov, who commented that in *From the Earth to the Moon*, Jules Verne had envisaged a three-man crew for his spaceship - English, French and American. The Russians were so backward then that Verne did not think to include a representative aboard his lunar vehicle! It is intersting to note that his niece was later able to send a telegram to Gagarin with the remark, "You turned a dream into reality."



A half-scale model of the Luna 16 sample-return craft. The return sphere and its propulsion unit sit on top of the lander.

Natko Bjelcić

VON KÁRMÁN ANNIVERSARY

Theodore von Kármán, one of the founding fathers of modern astronautics, was born 100 years ago.

In Hungary and Germany during the early years of this century, he was involved in teaching and researching aerodynamics but a visit to America in 1926 led to his most notable contributions to astronautics. In 1930 he was invited to become director of the Guggenheim Aeronautical Laboratory of the California Institute of Technology, becoming a US citizen in 1936.

He enthusiastically supported a group of his students in their interest in rocketry and within two years the US Army Air Corps founded a project which led to the JATO (jet-assisted take-off) aircraft rockets being developed. In 1944 he was a co-founder of the new world-renowned Jet Propulsion Laboratory which conducted the first governmental long-range missile and space exploration research programme.

Von Kármán was born in Budapest on 11 May 1881 and returned to Europe where he died in Aachen, West Germany on 6 May 1963. His vital contributions to modern astronautics were recognised by one of the ultimate accolades - a crater on the Moon now bears his name.

SPACE IN THE UK

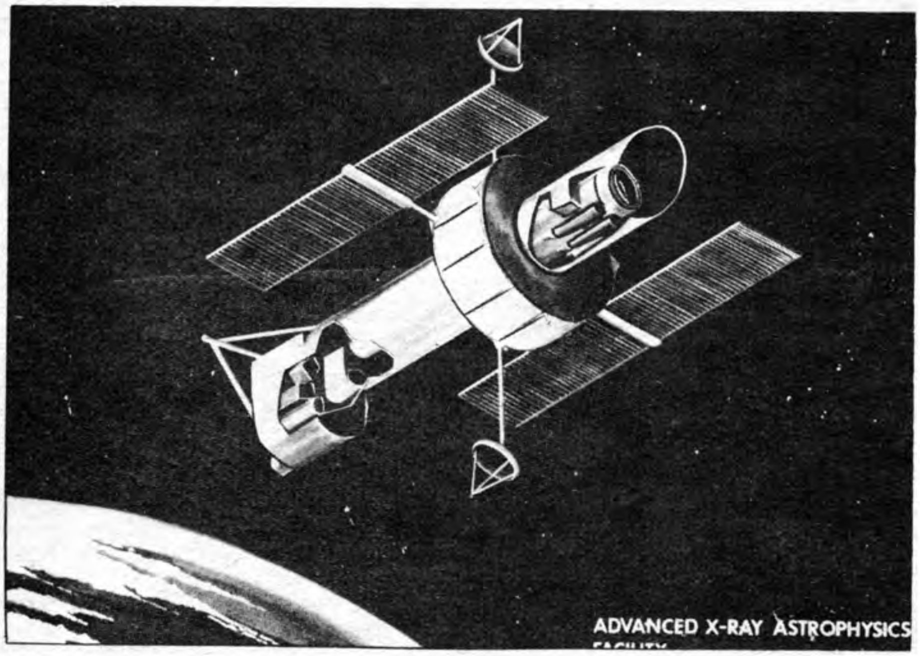
The space activities of the UK's Electronic Engineering Association (EEA) - which has companies such as British Aerospace, Marconi and Plessey as members - are now conducted through the United Kingdom Industrial Space Committee (UKISC) to which companies belong in their own right. Policy maters are decided by the EEA Council; where appropriate. UKISC provides the industry representatives to the main interface with Government, the Joint Space Group.

Members of UKISC met the Secretary of State for Industry and his ministerial and departmental advisors in April 1980 to discuss the need to establish a co-ordinated approach to satellite system requirements across all Departments and to establish short and long term objectives. Additionally, the Committee submitted papers to the Central Policy Review Staff Study set up last July by the Under Secretary of State for Industry to undertake a general survey of space activities in the U.K.

FUELLING SATELLITES

Fitting pyrotechnics and loading fuel into tanks has always been left as late as possible before a satellite is launched because of the dangers involved. Many satellites use hydrazine propellant, a highly sensitive substance, for their attitude control systems.

Marconi Space and Defence have now developed a remote-



NASA's Marshall Space Flight Center has come up with this proposal for a new X-ray astronomy satellite, known as the Advanced X-Ray Astrophysics Facility. It could be launched in 1989 to provide data on high-energy processes occurring in the Universe.

controlled loading cart which should reduce the dangers involved. The cart's fuel reservoir is constantly weighed to determine how much fuel the satellite has taken aboard, a quantity which needs to be known within an accuracy of about 99.95%.

Technicians have no need to be present at the loading but can watch from the safety of a control room.

ESA used the cart for the first time to load 40 kg of hydrazine aboard Meteosat 2 before its launch by Ariane 03 and will probably use it for the Marecs maritime satellite and the Italian Sirio comsat.

DIAMONDS FROM SPACE

Tiny crystals of diamond, formed in an ancient cosmic catastrophe, have recently been found in a 10.4 kg (23 lb) iron meteorite collected from the antarctic ice cap in 1977. This is only the second iron-type meteorite discovered to have diamonds within it. The other, the Canyon Diablo, was much larger on impact.

Diamonds within the Canyon Diablo are belived to have been produced as a result of the shock pressure of impact when it hit the Earth. The antarctic meteorite is much smaller and would not have produced a sufficient shock when it hit the Earth - the diamonds must therefore have been produced as a result of a collision in space.

The diamonds, a type of crystalline carbon found at high pressures, were discovered as tiny crystals in small carbon-rich fragments found inside the nickel-iron metal making up the meteorite. They were discovered when a saw used to slice the meteorite came up against one of the diamond-bearing regions and refused to cut further. X-ray studies then established the presence of diamond, together with two other forms of carbon.

The meteorite is perhaps a fragment of an asteroid and the diamonds in it bear witness to a great collision which took place in the asteroid belt many millions of years ago. Diamonds form only at high pressures, such as those existing deep within the Earth. In a small object like a meteorite, such pressures can be supplied only by intense shock waves produced as asteroids collide with each other - or with the Earth - at speeds of tens of thousands of miles an hour.

The diamond-bearing metorite was collected in 1977 from the Allan Hills region of the Antartic, where more than a thousand new meteorite specimens have been found since 1976. Only nine of these meteorites are of the metallic (iron) type; the remainder are various kinds of stony metorites. Some of the special meteorites found include an extremely well-preserved carbon-rich specimen, a new family of stony meteorites, another puzzling stone that seems almost 3 thousand million years younger than other meteorites, and one that was preserved in the Antartic ice for almost 1.5 million years.

IN THE PAST

20 years ago.....
Gherman Titov gegins the world's fourth manned spaceflight on 6 August 1961, and spends 4 days/17 revolutions in space.

15 years ago.....
In the summer of 1966 two American astronauts were attempting space tag with three spacecraft. Gemini 10 was launched on 16 July 1966 on a three day multiple-rendezvous docking and EVA MISSION. Astronaut John Young was on his second flight and rookie Mike Collins was making his debut. Rendezvous and docking was accomplished with Agena 10, followed by rendezvous with Agena 8, in preparations for the later Apollo programme in which both men would play a vital part.

10 years ago.....
Scott and Irwin become the 7th and 8th men on the Moon. They begin their 12-day flight on 26 July 1971 and make three lunar EVAs before lifting off in the LM *Falcon*. None remained with NASA to make later flights - remember the so-called 'Apollo 15 stamp scandal'?

5 years ago.....
While NASA was scoring magnificent successes with landing Viking craft on the Martian surface, Soyuz 21 cosmonauts Volynov and Zholobov were occupying Salyut 5 and Luna 24 soft-lands on the Moon during 18 August 1976.

D.J. SHAYLER

SATELLITE DIGEST — 147

A monthly listing of all known artificial satellites and spacecraft. A detailed explanation of the information presented can be found in the January, 1979 issue, p. 32.

Robert D. Christy

Continued from May issue

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin- ation (deg)	Nodal Period (min)	Launch site, launch vehicle and payload/launch origin
Cosmos 1237 1981-1A 12130	1981 Jan 6.51 14 days (R) 1981 Jan 20	Cylinder+sphere +cylinder-cone? 6000?	6 long? 2.4 dia?	194 355	385 415	72.88 72.86	90.36 92.31	Plesetsk A-2 USSR/USSR (1)
Molniya-3 (14) 1981-2A 12133	1981 Jan 9.62 12 years?	Cylinder-cone+6 panels? 2000?	4.2 long? 1.6 dia?	436 448	40789 39922	62.81 62.79	735.49 718.09	Plesetsk A-2-e USSR/USSR (2)
Cosmos 1238 1981-3A 12138	1981 Jan 16.37 30 years?	Cylinder? 550?	2 long? 2 dia?	404	1956	82.98	109.05	Plesetsk C-1 USSR/USSR
Cosmos 1239 1981-4A 12140	1981 Jan 16.50 12 days (R) 1981 Jan 28	Sphere+cylinder- cone? 5500?	5 long? 2.4 dia?	213	234	82.34	89.04	Plesetsk A-2 USSR/USSR
Cosmos 1240 1981-5A 12143	1981 Jan 20.46 28 days (R) 1981 Feb 17	Cylinder+sphere +cylinder-cone? 6000?	6 long? 2.4 dia?	167	361	64.90	89.80	Tyuratam A-2 USSR/USSR (3)
Cosmos 1241 1981-6A 12149	1981 Jan 21.35 1200 years	Cylinder? 700?	2 long? 2 dia?	976	1010	65.82	104.98	Plesetsk C-1 USSR/USSR (4)
Progress 12 1981-7A 12152	1981 Jan 24.596	Sphere+cone- cylinder 7000?	8 long 2.2 dia	181 246 294	282 310 319	51.66 51.67 51.62	89.07 90.02 90.59	Tyuratam A-2 USSR/USSR (5)
Cosmos 1242 1981-8A 12154	1981 Jan 27.62 60 years	Cylinder+2 panels? 2500?	5 long? 1.5 dia?	625	655	81.18	97.59	Plesetsk A-1 USSR/USSR (6)
Molniya-1 (49) 1981-9A 11256	1981 Jan 30.68 12 years?	Cylinder-cone+6 panels+2 antennae 1800?	4.2 long 1.6 dia	428	40804	62.83	735.63	Plesetsk A-2-e USSR/USSR (7)
Cosmos 1243 1981-10A 12160	1981 Feb 2.09 2½ orbits?	Cylinder?		296	1015	65.82	97.85	Tyuratam F-1-m USSR/USSR (8)
Intercosmos 21 1981-11A 12162	1981 Feb 6.33 6 years	Octagonal ellipsoid? 550?	2 long? 1.5 dia?	473	514	74.04	94.53	Plesetsk C-1 USSR/USSR (9)
Kiku 3 1981-12A 12295	1981 Feb 11.354 indefinite	Cylinder 640	2.8 long 2.1 dia	258	36253	28.61	641.28	Tanegashima N-2 Japan/ Japan (10)
Cosmos 1244 1981-13A 12297	1981 Feb 12.77 1000 years	Cylinder? 700?	2 long? 2 dia?	965	1009	82.96	104.89	Plesetsk C-1 USSR/USSR (11)
Cosmos 1245 1981-14A 12299	1981 Feb 13.47 14 days (R) 1981 Feb 27	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	196 346 354	377 423 415	72.84 72.84 72.84	90.29 92.30 92.30	Plesetsk A-2 USSR/USSR (12)
Cosmos 1246 1981-15A 12301	1981 Feb 18.38 23 days (R) 1981 Mar 13	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	195	265	64.88	89.11	Tyuratam A-2 USSR/USSR (13)

Cosmos 1247 1981-16A 12303	1981 Feb 19.42 12 years?	Cylinder-cone + 6 panels? 1900?	4 long? 1.6 dia?	607 621	39231 39734	62.93 62.95	707.32 717.77	Plesetsk A-2-e USSR/USSR (14)
Hinoturi 1981-17A 12307	1981 Feb 29.40 50 years	Cylinder?	1 long? 1 dia?	573	639	31.35	96.65	Kagoshima Mu-3S Japan/Japan (15)
Comstar 1-D4 1981-18A 12309	1981 Feb 21.974 indefinite	Cylinder 1516	6.1 long 2.44 dia	553 35385	36519 35788	20.67 0.20	652.25 1425.80	ESMR Atlas Centaur Comsat/Nasa (16)
 1981-19A 12315	1981 Feb 28.8	Cylinder 13300?	15 long? 3 dia?	134	332	96.38	89.22	WSMR Titan 3 D DoD/USAF (17)
Cosmos 1248 1981-20A 12317	1981 Mar 5.63	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	171	345	67.14	89.69	Plesetsk A-2 USSR/USSR (18)
Cosmos 1249 1981-21A 12319	1981 Mar 5.82	Cylinder?	6 long? 2 dia?	251	264	64.99	89.66	Tyuratam F-1 USSR/USSR (19)
Cosmos 1250- 1257 1980-22A – H 12320-12327	1981 Mar 6.48 10,000 years?	Spheroids? 40 each?	0.8 long? 0.6 dia?	1391 1405 1420 1433 1447 1440 1456 1468	1472 1473 1472 1473 1472 1483 1478 1481	74.03 74.05 74.04 74.03 74.03 74.03 74.03 74.03	114.52 114.68 114.84 114.99 115.14 115.19 115.31 115.47	Plesetsk C-1 USSR/USSR (20)
Soyuz-T 4 1981-23A 12334	1981 Mar 12.792	Sphere + cone- cylinder + 2 wings 7000?	7 long? 2.2 dia	185 245 338	222 316 350	51.61 51.61 51.62	88.50 90.06 91.35	Tyuratam A-2 USSR/USSR (21)
Cosmos 1258 1981-24A 12337	1981 Mar 14.70 2½ orbits?	Cylinder?		301	1024	65.83	97.99	Tyuratam F-1-m USSR/USSR (22)

Supplementary notes:

(1) Orbital data are at 1981 Jan 6.6 and January 7.2.

(2) USSR communications satellite. Orbital data are at 1981 Jan 9.7 and Jan 16.3.

(3) Manoeuvrable reconnaissance satellite.

(4) Target for Cosmos 1243 in test of the USSR's satellite interception system.

(5) Unmanned ferry carrying supplies to Salyut 6. Progress 12 docked with the space laboratory at Jan 26.664. On Jan 28/29, Progress 12 raised the orbit of Salyut 6 to 348 × 360 km, 91.56 min. Orbital data are at 1981 Jan 24.8, Jan 25.0 and Jan 27.2.

(6) Probably an electronic ferret.

(7) USSR communications satellite.

(8) Cosmos 1243 was a test of a satellite interceptor, using Cosmos 1241 as its target. The interception was made at the beginning of the third orbit of Cosmos 1243, which then manoeuvred into a re-entry trajectory.

(9) Scientific satellite built and launched by the USSR, but also carrying equipment built by Czechoslovakia, East Germany, Hungary and Roumania. The satellite is studying the Earth's surface and the oceans.

(10) Technical experimental satellite carrying a plasma engine and other test equipment.

(11) Navigation satellite

(12) Orbital data are at 1981 Feb 13.5, Feb 14.6 and Feb 15.0

(13) Manoeuvrable reconnaissance satellite

(14) Probably the first in a new phase of early warning satellites. Orbital data are at 1981 Feb 20.0 and Mar 3.4.

(15) Scientific satellite carrying an X-ray telescope and a spectrograph for solar studies.

(16) Communications satellite owned by COMSAT. It is intended to be stationed at 127 degrees west longitude.

(17) US 'Big Bird' reconnaissance satellite.

(18) Manoeuvrable reconnaissance satellite.

(19) Radar carrying ocean survey satellite powered by a nuclear reactor.

(20) Multiple launch of small communications satellites; one orbit is shown for each.

(21) Manned spacecraft carrying Vladimir Kovalyonok and Viktor Savinikh to Salyut 6, in preparation for further flights of international crews. Soyuz-T 4 docked with Salyut 6 at 1981

Continued on p. 236

SOCIETY MEETINGS

INFRA-RED SATELLITE

The past few years have seen the rapid growth of the 'new astronomy' — observations in the spectrum outside of the visible region. Satellites have made surveys in X-ray (Explorer 42 and HEAO, etc), UV (IUE), gamma and radio waves, for example, but the Infra-Red section has been neglected by comparison.

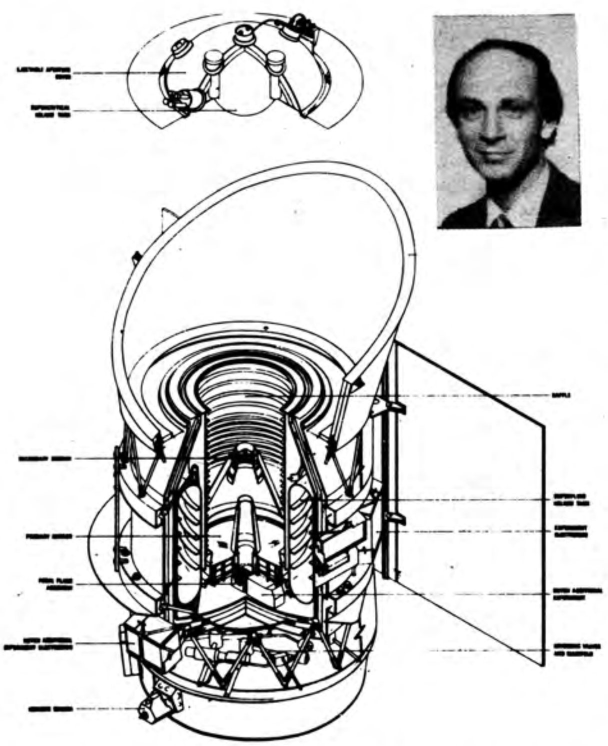
A talk given by Dr. Richard Holdaway* of the Rutherford Laboratories to the BIS in its Golovine conference room on 8 April, and chaired by Tim Grant, gave members an idea of the problems in building and operating a satellite designed specifically for an Infra-Red sky survey.

Very little IR radiation reaches the ground and until now much of the work has been performed by telescopes taken aloft by large balloons. By floating above the denser absorbing layers of the atmosphere in this way we have detected about 2000 IR objects. These flights last for only a few hours whereas a satellite would be able to operate for months or years and greatly extend our knowledge of the IR sky.

What kind of objects can we expect to detect in IR? Clouds of dust and material contracting to form new stars will gradually increase in temperature and will be detectable by their output of IR (i.e., heat) radiation before we can see them in any other way. At the opposite end of the chronological scale, stars in the process of dying will also be bright in IR. Both events should be relatively common towards the centre of our Galaxy and since IR is less scattered by interstellar dust and gases we should be able to see them.

Other targets will include specific objects such as Seyfert galaxy NGC 1068, which we already know pours out significant amounts of energy from its nucleus in the IR, whereas dust clouds tend to obscure its visible radiation regions.

* *The opinions expressed in this report are not necessarily those of the speaker.*



Layout of the IRAS satellite. ***Inset:*** **Dr. R. Holdaway who described the project to BIS members.**

The purpose of IRAS (Infra-Red Astronomical Radiation) is to spend about 65% of its 12 month life making a survey of the entire sky between 8 and 120μm to allow an IR catalogue to be compiled. The rest of the time will be devoted to making specific observations suggested by investigators. The present launch date is August 1982, with a Delta 3910 taking the 1020 kg satellite into a Sun-synchronous 99° orbit from California.

Effectively, IRAS is a flying telescope but there are special problems in IR astronomy. All objects emit IR — including the satellite and telescope themselves. IRAS therefore has to carry 70 kg of liquid helium at a temperature near absolute zero (−273°C) to cool the equipment down and cut out unwanted radiation. Unfortunately, heat from the Sun and electronics will — despite insulation — boil the helium off after about a year, effectively bringing the mission to an end.

The telescope is a 60 cm diameter Cassegrain (Ritchey-Chretien type) with an array of 62 IR detectors covering an area 2.5 cm across located where an eyepiece would fit in an ordinary instrument. Other detectors will provide information on visible star positions so that the location of an IR source can be accurately determined. The detector — cooled down to 2 K by the helium — will also pick up satellites, asteroids and planets but later scans of the same region will eliminate them (the sources of interest will not have moved). Planners hope that the final catalogue will have about a *million* new sources.

The US and Netherlands are the main contributors to the $100M project. The Jet Propulsion Laboratory — in their first near-Earth space project — are providing the telescope and the Dutch are building the spacecraft to go around it. Britain's contribution (about 10% of the total even though we get one-third of the results!) is to provide the tracking and control station at the Appleton Laboratory, Chilton. After our experience with Ariel 6 we can do the job more cheaply than ESA's network. After every 12 hours observing period the data will be transmitted down in 8 minutes and an initial analysis lasting 3-4 hours will be made to see if anything interesting has been picked up.

The project began in 1973-4 with meetings between Dutch and US agencies and launch was scheduled for this year, but difficulties have forced delays. At the time of the BIS meeting, the telescope was only just ready for delivery to Fokker in Amsterdam for integration with the rest of the vehicle. The original designers were replaced by JPL. In addition, the glue used to attach the solar cells to their panels was the same as that NASA was using for sticking the thermal tiles onto the Shuttle — and supplies were short!

A practical problem occurs near launch because IRAS carries a liquid helium-filled cover across the top of the telescope aperture to keep the temperature down until orbit is achieved. Since the helium has been found to boil off more rapidly than expected, checkout will have to be completed in a few days instead of two weeks.

IRAS is one of the new astronomical observatories, together

with the Gamma-Ray Observatory and Hipparchos (ESA's astrometric vehicle). due for a 1980's launches which will extend our knowledge of the Universe.

ANDREW WILSON

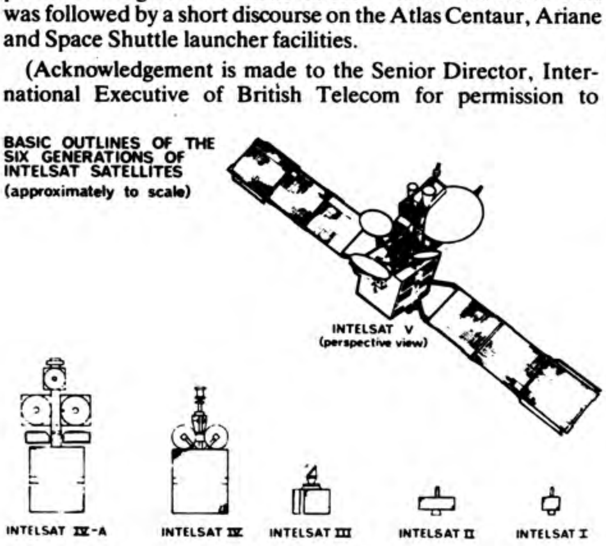
COMMUNICATIONS SATELLITE

An informative lecture illustrated with slides and films was given to the Society in the Golovine Lecture Room at HQ during the evening of 4 February by Peter Moss of British Telecom International, outlining the involvement of BTI in the development of satellite communications. It began with a review of the early years in which BTI (currently part of the British Post Office) played a leading role in experiments with passive and active telecommunications satellites. This led to the historic Telstar satellite which, placed in low Earth orbit, provided a limited communications capability between Europe and North America during periods of mutual visibility. Having established the viability of satelite communications, tests were carried out using satellites in geosynchronous orbit. This permitted continuous communications between participating Earth stations, culminating in the launch of the Early Bird satellite in 1965 and the creation of the international satellite organisation (INTELSAT) of which the United Kingdom is a founding member. The organisational structure and responsibilities of INTELSAT were discussed. This was followed by a review of the capabilities of the successive series of INTELSAT satellites through to the present Intelsat V and speculation on the future development of the system. Consideration was also given to the commensurate development of the Earth segment facilities which are in the main owned and operated by telecommunications organisations in the participating countries.

The talk then went on to set the background to the development of domestic and regional telecommunication satellite systems, with the proposed European regional communications satellite system being used as an illustration. The experimental Orbital Test Satellite (OTS) and its operational successor, the European Communications Satellite (ECS), were described, together with the creation of interim EUTELSAT which will mangage the system.

Attention was then transferred to the development of maritime satellite communications and the founding of the International Maritime Satellite Organisation (INMARSAT), responsible for global maritime satellite communications. This was followed by a short discourse on the Atlas Centaur, Ariane and Space Shuttle launcher facilities.

(Acknowledgement is made to the Senior Director, International Executive of British Telecom for permission to publish this item).



The Intelsat series of comsats. Intelsat I *(Early Bird)* was launched in 1965 and paved the way to the presently-used Intelsat V (first launched 6 December 1980).

MILITARY SATELLITE PROGRAMMES

On 23 January 1981 the second BIS Technical Forum meeting was held, the subject being Military Satellite Programmes. The meeting was chaired by Phillip S. Clark with three papers being presented:

The Space-Borne Angle Beacon (Tom M. B. Wright)
Soviet Early Warning Satellites (Geoffrey E. Perry)
American Photoreconnaissance Satellites (Anthony Kenden)

It is hoped that the papers will be published in the *Journal* at some future date.

After the three papers had been presented a general discussion took place, from which it transpired that although a number of members were carefully watching the behaviour of Soviet photoreconnaissane satellites, little similar work was being done (at that stage) on the American programme.

It is hoped that a further Technical Forum on the same subject will be held in the future. When the call for papers appears in the Society's publications it is hoped that there will be some contributions dealing with non-American and non-Soviet satellite systems, remembering that the Chinese have a satellite programme and there have been proposals for other nations to launch reconnaissance satellites.

'EUROPE IN SPACE'

A film show was held at the Society's Headquarters on 11th and 12th March 1981 with the theme 'Europe in Space'. Following technical problems encountered in the first showing, the film 'Sur Les Vois de l'Espace' had to be withdrawn from the second showing and another film substituted.

The films at the second showing were:

Europe in Space
TV Package - ELDO
OTS
Ariane
Discovery in Space

Unfortunately, it was realised too late that the content of the first two named films overlapped a great deal, the subject matter being the development in the 1960's of the ELDO programme. The films showed footage of the designing, testing and assembly of various Europa 1 components, culminating in the launch of a Europa-1 vehicle with only a 'live' first stage. The two films made very optimistic noises about the future successes of ELDO!

The OTS film followed the assembly and launch of ESA's Orbital Test Satellite, with both the initial launch failure and subsequent launch successes being shown. The applications of the satellite once on station were clearly depicted.

When one saw the Ariane film, one could not help but draw a comparison with the two ELDO films which had just been screened. The film covered the design and testing of the Ariane vehicle, its shipping to the launch site and the first successful launch at the end of 1979. After the meeting the chairman, Phillip S. Clark, expressed the hope that in 10-15 years members would not be viewing the Ariane film in the same light as they had viewed the ELDO films earlier!

The final film, 'Discovery in Space', was the only one which dealt with a purely British satellite: Ariel 3, launched in May 1967. The various experimenters discussed the equipment which the satellite would carry, and this was followed by the assembly and the testing of the satellite. The story then shifted to the United States, where Ariel 3 (or UK 3 as it was then known) was mated to the American Scout launch vehicle. The film ended with the successful launch and experimental returns of the first British-built satellite.

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Lecture
Title: **The ARIEL 5 and 6 EXPERIENCE**
by Dr. M.J. Ricketts

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **2 September 1981**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture
Title: **IT'S A SMALL UNIVERSE**
by M. Irvine

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **16 September 1981**, 7.00-9.00 p.m.

Admission is by ticket only. Members wishing to attend should apply in good time to the Executive Secretary, enclosing a reply-paid envelope.

Study Course

Theme: **REMOTE SENSING**

A course of eight evening meetings on the above topic, including a visit, will take place during the 1981-82 session. Details are as follows:

30 September 1981	What is Remote Sensing? by Dr. J. R. Hardy
28 October 1981	Platform, Sensors and Data Processing by Dr. J. R. Hardy
11 November 1981	Data Classification and Interpretation by Dr. J. R. Hardy
25 November 1981	Space Oceanography by Dr. J. O. Thomas
9 December 1981	Visit to the Laboratory for Planetary Atmospheres, Department of Physics and Astronomy, University College, London, accompanied by Dr. G. E. Hunt, 6.30-8.00 p.m.
6 January 1982	Remote Sensing: Needs & Applications in Developing Countries by Dr. E. C. Barrett
17 February 1982	Remote Sensing by Landsat and Weather Satellites by Dr. R. Harris
10 March 1982	Evening of technical films on Remote Sensing

The venue will be the Society's Conference Room at 27/29 South Lambeth Road, London, SW8 1SZ. Lectures will run from 7.00-9.00 p.m. Course Fee £5.00.

Application forms for registration are available from the Executive Secretary, Please send s.a.e.

32nd IAF Congress

The 32nd Congress of the International Astronautical Federation will be held in Rome, Italy from **6-12 September 1981.**

Theme: **SPACE: MANKIND'S FOURTH ENVIRONMENT**

devoted to "promoting awareness about the challenges and debating the problems posed by the use, further exploration and management of this fourth environment." The theme will then be developed through a series of symposia and technical sessions organised by the IAF and by the International Academy of Astronautics (IAA).

Members of the Society wishing to present papers are asked to notify Dr. L.R. Shepherd, Chairman of the BIS International Liaison Committee at Society H.Q. as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

36th Annual General Meeting

The 36th Annual General Meeting of the Society will be held in the Tudor Room, Caxton Street, London, SW1 on Saturday **26 September 1981,** commencing 3.00 p.m.

Details of the Agenda appear in this month's issue of *Spaceflight.*

First Night

An opportunity for new members of the Society (and their guests) to meet members of the Council and Officers of the Society will occur on **7 October 1981,** at the Society's HQ Building, 27/29 South Lambeth Road, London, SW8 1SQ, 7.00-9.00 p.m.

It will be an informal evening in which members can hear about the History and Activities of the Society, see a space film and have an opportunity for a short guided tour of the Building.

New members who would like to attend are invited to apply in good time, enclosing a reply-paid envelope.

Lecture
Title: **RECENT ADVANCES IN SPACE FLIGHT**
by P.S. Clark

A review of space activities throughout the world which have taken place during the past twelve months, to be held in the Golovine Conference Room, Society HQ 27/29 South Lambeth Road, London, SW8 1SQ, on **14 October 1981,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture
Title: **OBSERVATIONS OF THE ATMOSPHERE OF VENUS FROM THE PIONEER ORBITER**
by Dr. F.W. Taylor

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **18 November 1981,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

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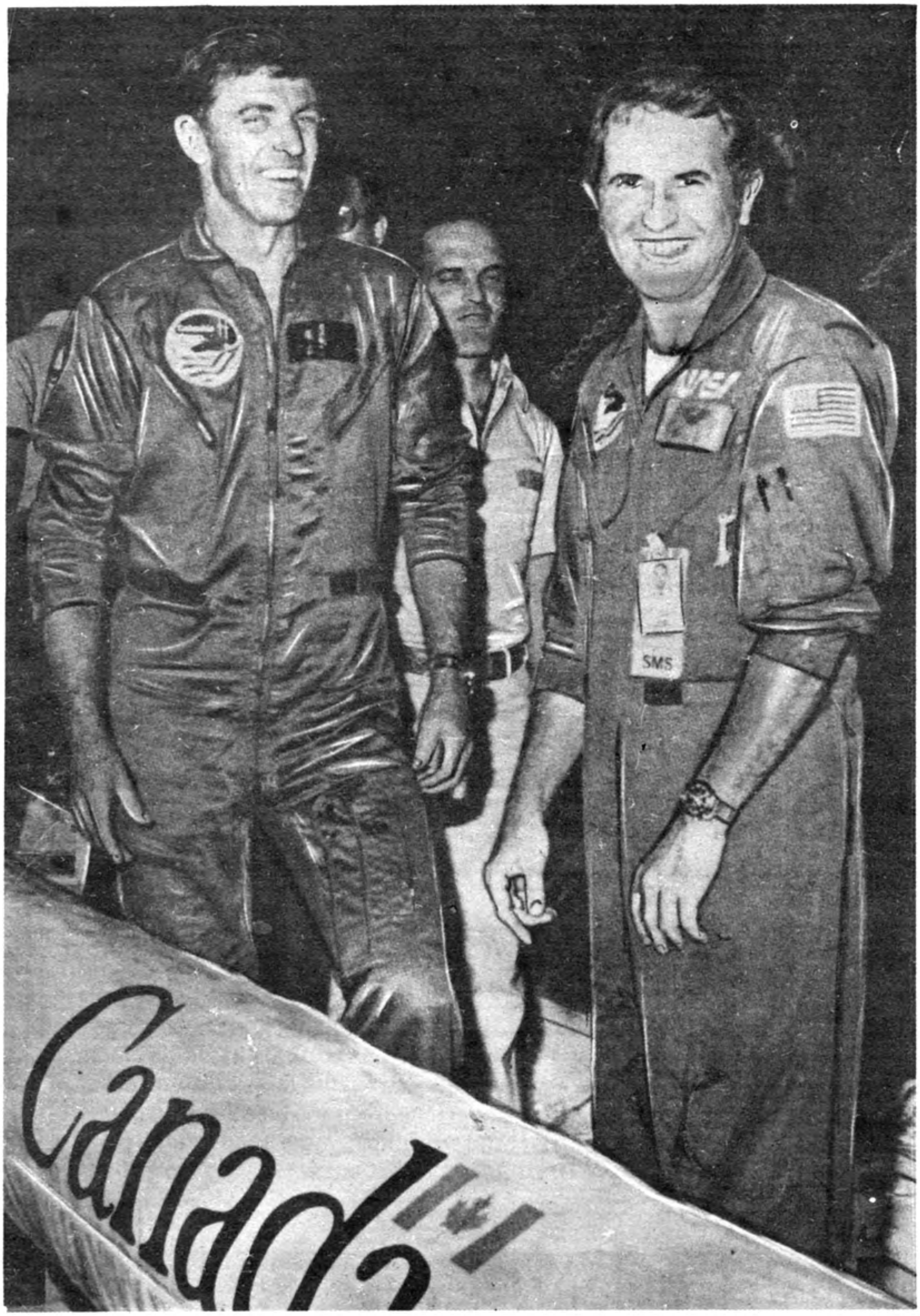
SPACEFLIGHT



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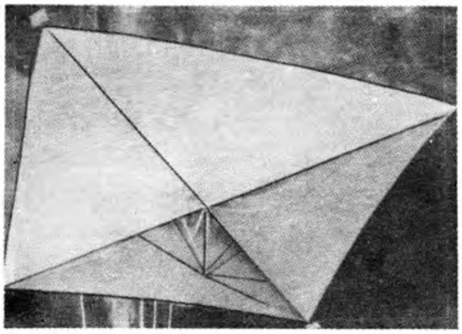
VOLUME 23 No. 8
OCTOBER 1981

SOLAR SAILING TO THE MOON

The BIS Space Technology Committee is currently reviewing a proposal from several CNES (French Space Agency) engineers for a very interesting project: no less than racing solar sails to the Moon after launch by an Ariane rocket in 1985.



The idea of using the pressure of light from the Sun to drive a spacecraft has been well known for many years. Many theoretical studies have been conducted in the US, Europe and the USSR. Recently these studies have come closer to technical reality due, in large measure, to the work of Eric Drexler, of M.I.T., and Robert Staehle, of the World Space Foundation. In 1979, contacts were made to investigate the possibility of flying an experimental solar sail on board a 1982 Ariane flight, but time proved to be too short and the project was dropped.

The idea was revived once more in 1980, this time with a new twist: that of racing several sails together to the Moon.

Besides testing a promising concept, a solar sail race to the Moon could have a dramatic popular impact, not least because the sails could be seen by the naked eye or with binoculars during the many months they would take to reach the Moon. This would bring the reality of space activities to billions of people. The effect would be beneficial - both politically and economically - for the space community.

Three sails could be launched in 1985 or later by Ariane IV. They would form the lower payload during a dual launch. A common apogee motor would raise the perigree to a few thousand kilometres (to avoid excessive atmospheric drag) and, after separation and deployment, the sails would be on their own.

The finishing line would be denoted by occulation by the Moon.

The projects themselves could be run by dedicated non-profit organised groups, very much in the same manner as the AMSAT or the OSCAR radio-amateur projects.

The cost of developing, launching and controlling the sails during flight would amount to several millions of dollars. A preliminary survey shows that this is comparible with the sums of money involved in maintaining a team of cars for Grand Prix racing - so commercial sponsorship might well be able to finance the project.

If enough initial support emerges, then CNES could be asked officially by the ANSTJ (Association Nationale Science, Technique Jaunesse) of France to undertake a feasibility study for the project.

The Society's Space Technology Committee has organised a meeting for 17 November to discuss the proposal. See p.281 for details.

SPACEFLIGHT

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CONTENTS

COVER

Astronauts for the second Shuttle mission *left* is Joe Engle, flight commander, *right* is Dick Truly, pilot. They are standing next to the Remote Manipulator System arm during its installation in *Columbia* last June in the Orbiter Processing Facility.
NASA

MILESTONES

May 1981

23 The second Intelsat V comsat is launched by Atlas-Centaur. It will be in the main link over the Atlantic because the first V, launched 6 December last year, is having hardware problems.

31 India launches her second satellite into a 364 x 181 km orbit. The 84 lb craft should have entered a 834 x 296 km orbit and the low perigree leads to reentry on 8 June.

31 An object is observed to separate from Salyut 6. Analysts believe it may be the orbital module of Soyuz T-4 (which left on 26 May).

June 1981

1 Contract begin-date for work by Convair on converting the Centaur upper stage for use aboard the Shuttle. There are some doubts, however, being expressed in Congress about using Centaur at all.

19 Explorer 55 reenters after 5½ years of probing the upper atmosphere.

19 Ariane L03 is successfuly launched from Kourou at 12.33 GMT and takes three satellites into a 201 x 36,207 km orbit. Meteosat 2 (an ESA weather satellite) fires its apogee motor on 20 June, followed by Apple (an Indian comsat) on 21 June, to enter geostationary orbit. Preliminiary examination of launch data shows no problems. Ariane L04 is scheduled for November.

19 Cosmos 1267, launched on 24 April by a Proton rocket, docks with Salyut 6 in a 332 x 360 km orbit. The new vehicle, described as "a prototype space module" by cosmonaut Konstantin Feoktistov, nearly doubles the size of the space station and is an important step towards building permanent orbital bases. On 30 June engines aboard the new module fire to raise the orbit to 339 x 386 km.

30 ESA's Council, the body which formulates ESA policy and rules in scientific, technical, administrative and financial matters, elects Prof. Hubert Curien (France) as its Chairman.

30 The Shuttle External Tank is mated with the stacked Solid Rocket Boosters on the mobile launch platform in the VAB for STS-2.

July 1981

1 The OSTA-1 payload for *Columbia's* second mission is inserted into the cargo bay.

В журнале не печатается ряд страниц.

NEW MEMBER SERVICES

NEW-STYLE SOCIETY TIES *See 279*
SWEATSHIRTS *See 281*
JBIS AND SPACEFLIGHT BINDERS *See 283*
MAJOR MEETING: SPACE '82 THE FUTURE OF MANKIND *See Inside Back Cover*

ORBITAL CONSTRUCTION

By Gerald I. Borrowman

Introduction

Man, the consummate builder, is about to erect space systems so large, massive and complex that placement in orbit can be accomplished only by construction in space. The history of civilization has been characterised by the erection of colliseums, skyscrapers and suspension bridges. In the next two decades of the twentieth century, astroworkers, through the benefits of weightlessness, will be able to assemble enormous structures in orbit. These tasks include the erection of large vehicles or structures in low Earth orbit. Manned and unmanned space platforms, requiring piecemeal assembly, and large space-based antennae of several hundred feet in diameter, which could support major civil communications and military radar surveillance missions are among the objectives. Large demonstration modules of future solar power satellites will be assembled to prove the feasibility of tapping the Sun's limitless energy, to provide electrical power to Earth.

The Space Transportation System will provide the means of commuting to an orbital construction site (with people and material). As NASA payload planning for the 1980's more sharply defines the set of factors driving the use of Shuttle, the difficulty of keeping the Shuttle spaceborne for extended periods will collide with the desire for longer-duration experiments. Efficiency of both transportation and orbital activity is expected to increase if regular two-way flights are made to a single point in space. Equipment failures would be remedied sooner if the equipment is concentrated there.

These facts and speculations reinforce the rational that there should be a place in space where payloads can be left by the Shuttle.

Erecting a Space Platform

According to William Cuneo, Assistant for Mission Planning of NASA's Space Systems Division, "a platform could be erected in principle from a single Shuttle flight. At this stage of design we might be too optimistic about how much we can reasonably stuff into the Shuttle, so perhaps you need to involve two flights. Shuttle revisits for changeout or repair could also carry up and leave additional parts to expand the platform.....

"The propulsion for the platforms is commonly envisaged now as a conventional storage system using monomethyl hydrazine and nitrogen tetroxide with an optimum specific impulse of about 290..... Altitudes of 900 km and high inclinations (100°) are typical. Such altitudes and inclinations make it undesirable to fly a 6,000 kg Shuttle up to a high platform of much less mass" [1].

NASA has underway a Space Structures Test Program. Acording to Richard Kline, large structures should be recognised as unique because of their need to be matched to the space environment and cannot be tested for inflight performance on the ground. Both ground and space test programmes will be required to build confidence in orbital structures. This programme will include the testing of the tools of the satellite service elements and techniques required by the Shuttle such as the Manned Manoeuvring Unit and the Cherrypicker will be indispensible for large structures technology development.

NASA is preparing a series of automatically unfurled equipment which will facilitate the assembly of prefabricated parts. A deployable antenna with a diameter between 150 and 300m would be constructed through the use of tension members. It would resemble a gigantic bicycle wheel.

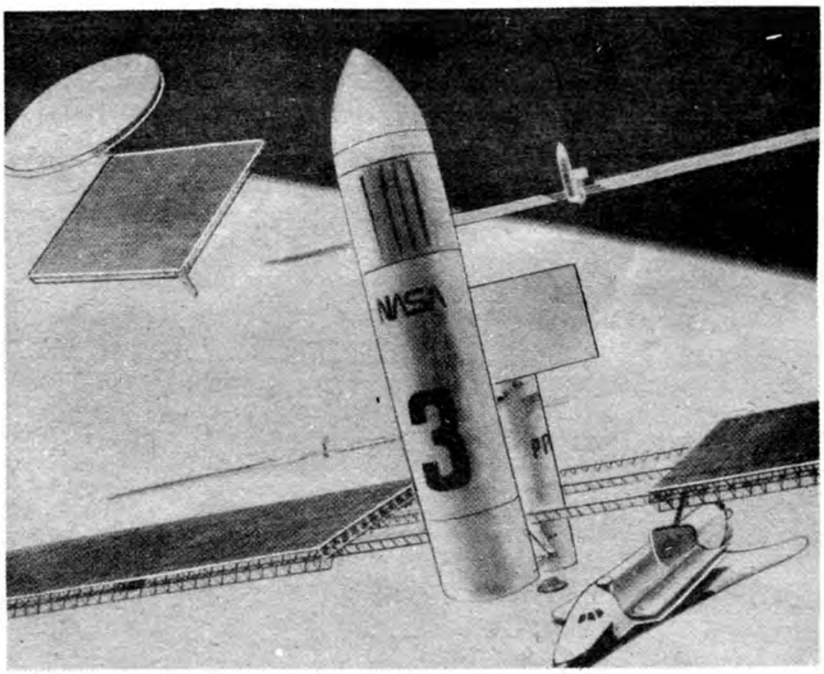
The antenna would be launched in the Space Shuttle's payload bay in a compact bundle. The package would have a diameter of about 1.3m, length of 8.6m and weight about 11,040 kg. The rate of unfurlment would be controlled by the rate at which each of the stays are deployed. The webs forming the mesh of the stays are wrapped around a central drum and unwind as each of the straight members of the rim expand outward from the centre.

The deployed antenna would have the ability to focus beams to the ground from geosynchronous altitude.

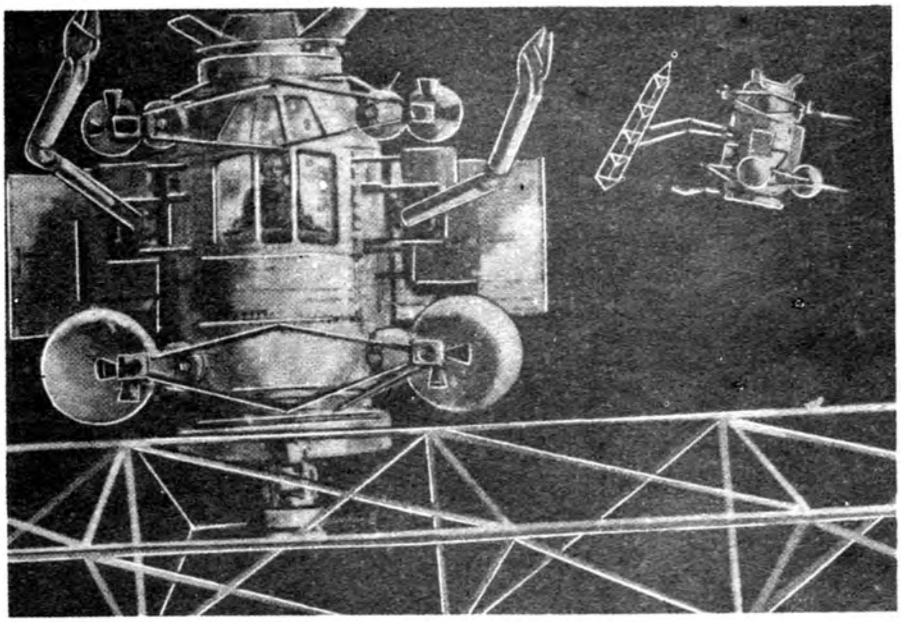
The Beam Builder

A beam builder will add a significant capability to space fabrication activity.

General Dynamics Convair Division recently completed a study that defined the techniques, processes and equipment



The External Tanks of future Shuttles may be taken into low Earth orbit instead of being allowed to fall to destruction in the Atlantic down-range from Canaveral. Once in space, the Tanks could be converted into large habitation modules for space stations in an exercise reminiscent of the "West Workshop" designs for Skylab over a decade ago.



Right: A free-flying closed cockpit cherry-picker would enhance crew productivity and reduce hazardous operations in space construction. The enclosed cherry-picker would contain a life-support system capable of supporting a two-man crew. *Below right:* The automated beam builder in an artist's conception of its initial test operation from the payload bay of the Space Shuttle. An aluminium beam builder underwent ground test at the Marshall Space Flight Center during 1978.

Courtesy Grumman Aerospace.

required for automatic assembly of structural elements in space.

The Space Construction Automated Fabrication Experiment Definition Study (SCAFEDS) described the initial orbital test operations of the automated beam builder from within the cargo bay of the Space Shuttle. Once deployed from the stowed position, the beam builder would be moved to successive positions along Shuttle-attached assembly jigs to automatically fabricate four triangular beams; it then fabricates the first of nine shorter cross-beams. The partly completed assembly is then automatically transported across the face of the assembly jig to the next cross-beam location where another cross-beam is made and installed. This process repeats until the 'ladder' platform assembly is complete.

The SCAFEDS will open the new discipline of space construction. The beam builder, a rudimentary construction facility (or 'jig'), and a construction crew would be evaluated as well as the construction techniques. This experiment, which might be flown in 1983-84, would be close to the upper limit for single-Shuttle flight experiments.

The first beam would be subjected to dynamic response tests to determine its characteristics with data fed to the ground to compare with predicted behaviour; and within three days a platform would have been constructed, crew members performing EVA to install test instrumentation, subsystems and free flight experiment equipment.

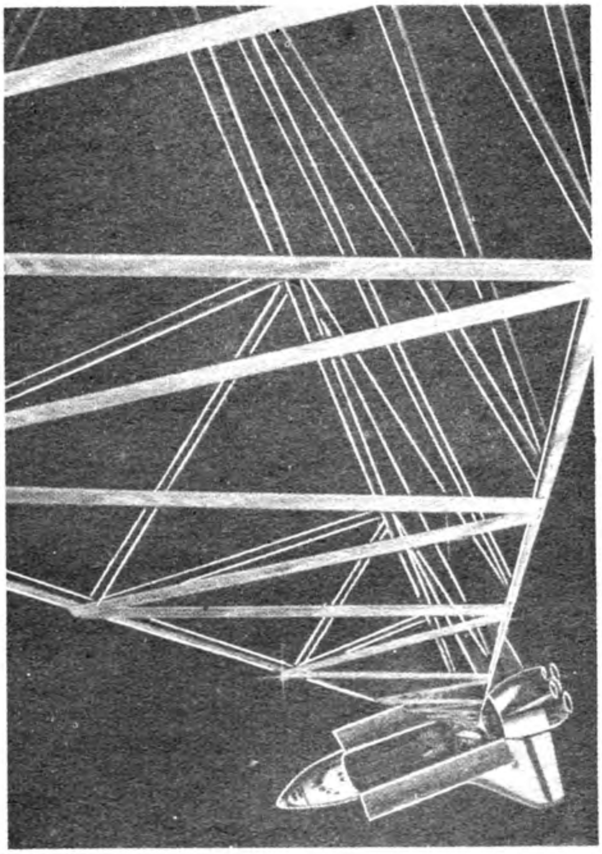
Separation and recapture of the experimental platform will allow dynamic response and thermal deflection tests to be made. Another EVA will be performed to demonstrate possible unscheduled maintenance and repair activities.

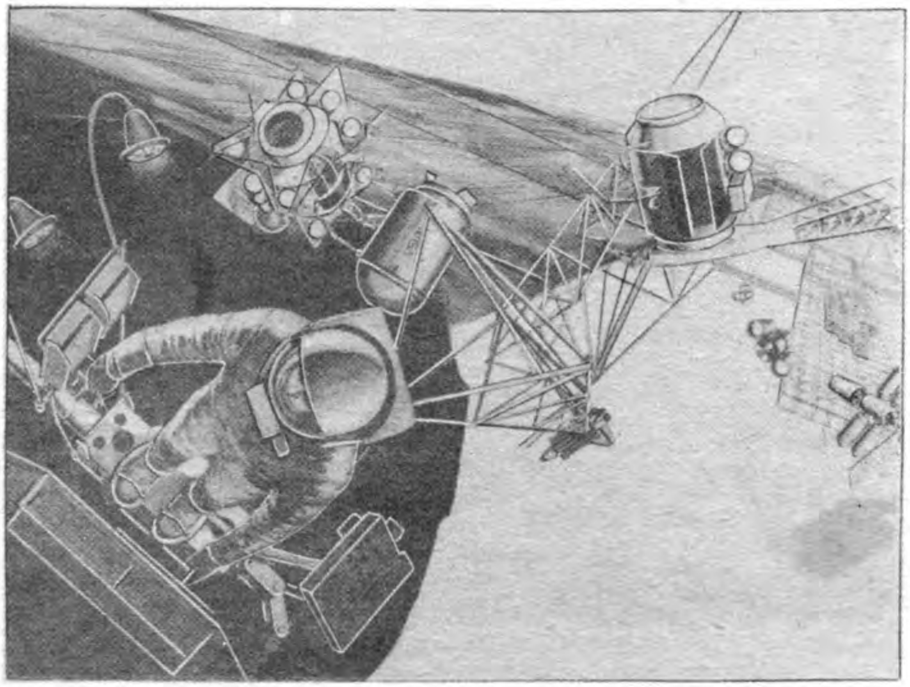
However, the spectrum of space construction operations will be exceeded when the opportunities from the Shuttle are exceeded. The next step would include a warrant of a space construction platform to permit the semi-automatic assembly of large platforms.

The 3.0 m wide by 4.27 m long and 7,272 kg beam builder has successfully demonstrated on the ground that basic building block structural elements can automatically be produced. The aluminium beam builder made its first beam on 4 May 1978 at the Marshall Space Flight Center [2].

The beam builder forms longitudinal members of the beam from flat stock. The flat stock is fed into the rolling mills from three reels. Each reel can hold 300 m of 4 mm thick flat aluminium stock and be replaced by another when depleted.

Three sets of magazines store the vertical and diagonal cross braces. Each magazine holds approximately 200 cross braces, enough to make 300 m of beam. A cross brace dispensing mechanism moves one cross brace into position to be picked up by a carriage which transports the it from the magazine to its place on the beam cap member.





A montage of various orbital construction aids and devices. In the lower left hand corner is the Manned Remote Work Station mounted on the end of the Remote Manipulator System. The closed cockpit cherry-picker is shown in a free-flying version as well as being mounted on a dexterous arm. In the centre of the picture is a beam builder in operation from the Shuttle payload bay.

Grumman Aerospace

Clamping and series spot welding of the cross braces is accomplished with a single mechanism. With the carriage mechanism holding a cross brace in place on the beam cap member, a block moves into place and clamps the brace to the beam cap member, at which time the carriage mechanism releases the cross brace and retracts to its reset position, where it is ready to receive the next brace. Once the block is in position, the series spot weld cycle begins with each pair of electrodes being activated individually until six spot welds are accomplished at each end of each cross brace. All vertical cross braces are dispensed, clamped and welded in place before the same sequence of events takes place for the diagonal cross braces.

Once the desired length of beam has been produced, beam cutoff is accomplished by three guillotines which slice through the three beam cap members.

Automatic control is by means of a simple commercial computer which monitors all of the functions of the aluminium beam builder. Each function, from rolling the proper length of beam cap member to form one beam length, through cross brace dispensing and welding and beam cutoff, is monitored and registered as completed before the next function is initiated [3].

The origins of the beam-builder can be found, in the spring of 1974, when Grumman Aerospace engineers were studying the construction of large orbital space structures. Construction of Solar Power Satellites (SPS) requires the development of some sort of space beam builder. Ultimately, structural beams will be available on-orbit in numbers sufficient to permit them to be assembled like a giant erector set [4].

Astroworkers will be aided by a Manned Remote Work Station (MRWS) or open 'cherry-picker'. The basic cherry-picker will provide support for construction, maintenance, repair and servicing operation. Initially, the cherry-picker will be mounted on the end of the Shuttle's Remote Manipulator System (RMS) to provide a means of transporting an extravehicular astronaut with tool and mission hardware to extend the range of mobility. Such a cherry-picker will enhance productivity during (six-hour) EVA periods.

Anchored by a ski-boot like device to the platform, the astroworker will be provided with means for effective body stabilisation and positioning and a control-and-display console equipped with hand controllers and displays to permit him to 'fly' the cherry-picker. Two light stations will be mounted on the rear of the platforms and provide of illumination on the work site.

The open cherry-picker (OCP) will find a variety of uses during early Space Shuttle flights. The OCP could support routine replacement of consumables such as beam-builder casettes, camera batteries and film, as well as assembly work. The OCP will enhance Spacelab sortie mission operations by providing a means of deploying and retracting pallet-mounted experiments.

A stowed OCP would occupy a volume of 106 x 152 x 91 cm. It would be stowed in the forward starboard section of the cargo bay at the structural attachment points for the Manned Manoeuvring Unit (MMU). The overall mass of the OCP is approximately 270 kg.

Underwater simulation conducted at the Marshall Space Flight Center, using two astronauts, revealed the advantage of and OCP construction operation over a purely EVA operation. The exercise involved transportation of 10 m long truss girders from a stowage area in the Shuttle payload bay to a fixture where the beams were assembled. The time to perform this operation was 45 minutes, excluding an adjustment for attaching tethers. The basic time and motion data of this simulation were used to estimate the assembly time if the Shuttle RMS is used to transport the truss girders while one astronaut performs the assembly operations. In this case, the estimated time of assembly is reduced by approximately 29 per cent. However, the use of an OCP reduced assembly time by 33 per cent relative to the EVA operations. If more beam assemblies are included, a saving of as much as 50 per cent could be eventually realised [3].

By the late 1980's, a 250 kW Power Module System may be in orbit to provide the basic element of a Basecamp at low Earth orbit (LEO). The Basecamp will evolve from a free-flying Spacelab which could be Shuttle tended. The Basecamp and the Shuttle could provide a habitat for astroworkers during construction operations. Eventually, permanent habitats will be added and thus the capability for a three-shift construction operation will have evolved.

To support such a capability, the OCP must evolve into a closed-cabin unit in which the astroworkers will work shirt-

sleeved. A pressurized work station will eliminate the fatigue-factor of an astronaut overcoming the hindrances of a pressure suit. The closed cherry-picker would contain a life-support system and sport two dexterous manipulator-six feet long arm extenders. Special shielding built into the walls of the cabin would permit the astroworker to stay on the job despite potentialy hazardous radiation flares from the Sun.

The closed cherry-picker would have a 170 cm diameter, dictated by the need for a 1 m egress hatch at the top and bottom. The cabin height is 250 cm and has a volume of 4.76 m^3. The cabin atmosphere is a two gas system at 14.7 psi and all subsystems will be located in the aft equipment bay, with a separate heat rejection system. The overall mass of the CCP is approximately 2244 kg.

Optimum crew size for a CCP has yet to be determined through simulator systems.

SOC and SPS

The Space Shuttle will be used throughout the 1980's for initial space construction development and the actual construction of some operational systems. However, the capability of the Shuttle to support the construction of large and complex space systems under consideration is inadequate in its configuration, stay time, crew size and electrical power. However, a permanent construction facility could be utilised more effectively. A Space Operations Center would support the flight development of the construction equipment and operational techniques begun with the Shuttle, and then implement them to construct, check out and transfer large space systems to operational orbits.

The first functional requirement of a facility such as the Space Operations Center would be to support the engineering and development of space construction equipment and operational procedures. These include fabrication of members from raw stock, erection of structures from prefabricated components, deployment of pre-assembled folded members, and assembly of these members with subsystem components to produce complete space systems. The space construction equipment will include holding and alignment fixtures, beam-builders, manipulators, end-effectors and manned remote-work stations.

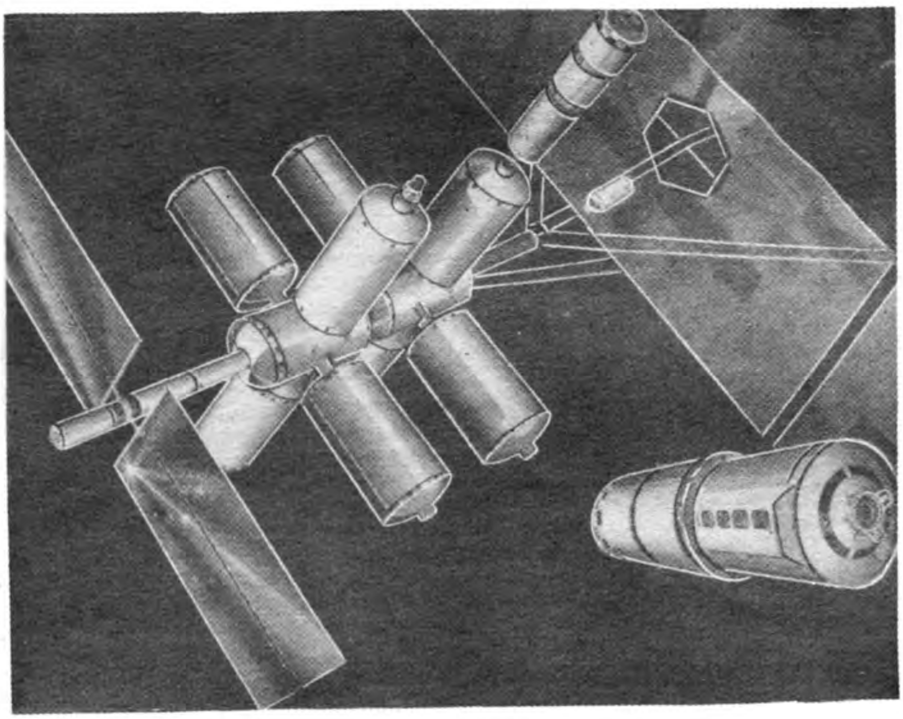
A second requirement is the construction of test systems for design verification. Such systems may be typified by the Solar Power Satellite (SPS) Article which is a complete, independent spacecraft approximately 200 m long. Its construction involves fabrication of triangular beams, connecting the beams to make a platform, installation of solar arrays, electrical conductors, and other subsystems, erection, installation, alignment and test of the microwave antenna, and installation of electric propulsion modules for orbital transfer.

Assembly of the modules of the SOC will be accomplished by docking the Orbiter to the Service Module and using its manipulator arms to remove the module from the payload bay and 'berth' it into the Service Module berthing port.

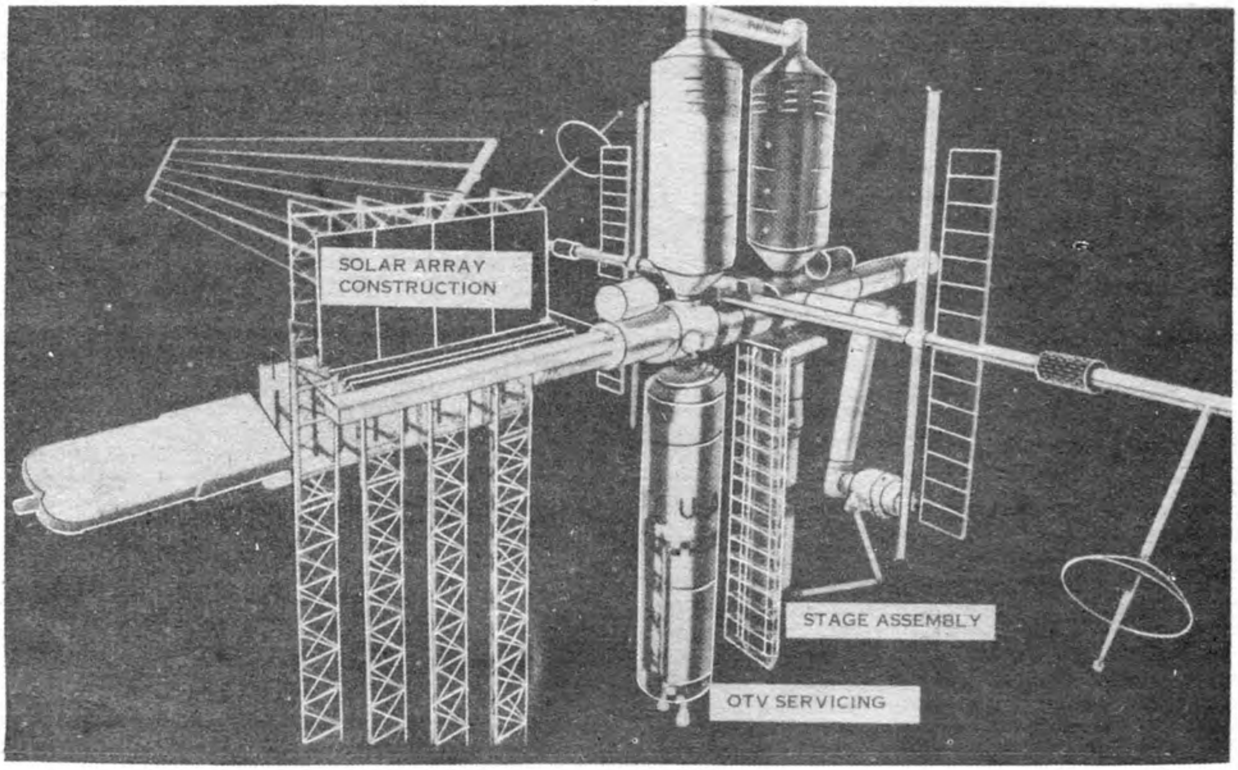
The SOC's initial construction facility concept consists of a Remote Manipulator and an operator's 'cab'. The cab will be berthed to the side of the SOC and the construction fixture (jig) berthed to the end part. A beam builder could be attached to the jig and positioned by a mechanism on the jig to fabricate the structural members 'in-site'. The RMS positions modules of mission equipment and subsystems on the constructed structure frame. The structural configuration is a 'ladder' about 200 m long and 10 m wide. The results would include operational test verification of all the construction equipment [4].

In 1895, Konstantin Tsiolkovsky, the theorist of interplanetary travel, published a paper "Day-Dreams of Heaven and Earth". As part of his detailed investigation of outer space he paid great attention to the methodology of his investigations. In his essay, Tsiolkovsky discussed the creation of an artificial Earth satellite. He also discussed the construction of a high tower and described what would happen as one ascended it.

"On the tower, as one climbed higher and higher up it, gravity would decrease gradually; and if it were constructed on the Earth's equator and therefore rapidly rotated together with the Earth, the gravitation would disappear not only because of the distance from the centre of the planet, but also from the centrifugal force that is increasing proportionately to that distance.



This artist's concept of a modular space station shows the utility of the Shuttle in placing large volumes in orbit. However, the volume constraints of the payload bay will eventually dictate on-orbit assembly of such structures. The androgynous docking system developed for the Apollo-Soyuz Test Project is shown on the crew transfer module.
Grumman Aerospace



A Space Operations Center would act as the base for building and checking out large space systems. This example shows a panel of a Solar Power Satellite (at left) being manufactured, and an Orbital Transfer Vehicle (OTV) being serviced.

"The gravitational force drops.... but the centrifugal force operating in the reverse direction increases. On the Earth the gravity is finally eliminated at the top of the tower, at an elevation of 5.5 radii of the Earth (36,000 km).

"As one went up such a tower, gravity would decrease steadily, without changing direction; at a distance of 36,000 km, it would be again detected.... but its direction would be reversed so that a person would have his head turned towards the Earth....." [5].

Arthur C. Clarke's *Fountains of Paradise* presents the reader with an eye-witness account of the construction of the first Orbital Launch Tower.

In a paper presented to the 30th International Astronautical Congress, Clarke suggested that, even with today's technology, we could build a structure one hundred times as high as the world's tallest building.

Clarke elaborated:

"But the geostationary orbit is a thousand times higher still, so we can forget about building up towards it. If we hope to establish a physical link between Earth and space, we have to proceed in the opposite direction - from orbit, *downwards* [6].

Hans Moravec, of the Stanford University's Artificial Intelligence Laboratory, has proposed the construction of non-synchronous skyhooks. Revolving about their own centre of mass, the skyhook could be used as a velocity bank, where spacecraft would deposit and borrow energy. Any velocity in the plane of the cable's rotation up to the cable's tip speed could be matched by the craft aiming for targets at various distances from the cable's centre. A series of such structures in successive circular orbits around the Sun, rotating and orbiting in the ecliptic plane, could provide a mode for conveying materials about the Solar System [7].

In the near-term, analysts foresee two Solar Power Satellites being built a year. Such an operation would require 275 million pounds of materials to be brought up on-orbit every year. These large masses dictate that the Shuttle will have to be replaced by a larger and more efficient vehicle which will be completely reusable [8].

Acknowledgements

The author wishes to express his gratitude for the cooperation provided by Charles Sheffield of the American Astronautical Society and Frederick C. Durant, of the National Air and Space Museum. William Cuneo provided invaluable insight into the development and utilisation of orbital platforms. Cuneo's office is searching for an imaginative name to be applied to the platforms.

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NEWS FROM THE CAPE

By Gordon L. Harris

MORE LAUNCHES

The Cape returned to more familiar business on 22 May with the launching of GOES-5, one of the newer generation of weather satellites, for the National Oceanic and Atmospheric Administration. The spacecraft will operate in geosynchronous orbit above Colombia observing weather over eastern North and South America.

One day later, an Atlas Centaur launched Intelsat V-B, the second of nine satellites owned and operated by the 105 nation International Telecommunications Satellite Organization. The craft weighed 1,928 kg and will accommodate 12,000 voice circuits and two colour television channels. It became the prime Intelsat satellite for communications between the Americas, Europe, the Middle East and Africa. Ford builds the Intelsat series using components developed by manufacturers in Japan, Italy, Germany, France and the United Kingdom.

GOES 5 will provide Earth images similar to those from GOES 4 over the Pacific. The second satellite will show the Americas (here at far right) in the centre of the picture.

SHUTTLE NEWS

Major changes in NASA's way of doing business are predicted by informed observers as the result of Shuttle success and the Reagan administration's choice of the new administrator and deputy administrator. The latter, German-born Hans Mark, leaves the post of Air Force Secretary to take NASA's No. 2 job "to assure utilization of the Shuttle by the military".

Once head of a NASA research centre, Mark surprised agency executives at a top level conference several years ago when he asked what role the agency should play in the event of war. No one had a good answer then, or now. But it is obvious that the military role in US space activities will increase as the Air Force begins to fly Shuttles out of Vandenberg Air Force Base in California for polar orbiting missions. Some defence payloads will also be carried into equatorial orbit by NASA-launched Shuttles from the Cape. Agency policy of full disclosure will inevitably give way to military secrecy concerning those payloads.

Giving the position to an aerospace executive, so the reasoning goes, means that Reagan believes industry should play a larger role in NASA's future, perhaps taking over Shuttle operations when *Columbia* completes the four-mission test series. KSC Director Richard Smith earlier announced plans to install three major contractors by 1984: one responsible for cargo processing, a second for general support, and another for Shuttle launch functions. All of which underlines NASA's determination to routinise Shuttle operations akin to those of commercial airlines.

YARDLEY LEAVES

Shuttle administrator John F. Yardley is returning to his former employer, McDonnell Douglas, to become president of its Astronautics Division. He managed the Shuttle programme since May, 1974. L. Michael Weeks will succeed him.

SPACE STATION

NASA and its supporters in the aero-space industry and Congress are trying to capitalise on *Columbia's* success by aiming for a major new programme: a "permanent" space station in Earth orbit.

Drum beating for this enterprise could be heard when the first Shuttle roared off the Cape in early April. Chairman Don Fuqua of the House Committee on Science and Technology declared that he favoured a big station.

So did Neil Armstrong, first man on the Moon, who also witnessed the launch. His words were echoed by other retired astronauts and Senator Harrison Schmitt of New Mexico, an Apollo 17 Moonwalker and space chairman of the upper House.

Shuttle pilots John Young and Robert Crippen followed the party line in testimony before Fuqua's committee on 20 May. "Building a manned station is the next logical step if this nation is to remain first in space," Crippen declared. "It is needed as an operations centre for continued exploration.

"The Shuttle gives us the capability to build a station and open horizons we can't imagine. But we've got to start now because it takes 10 years to develop something like that." To which Young added a fervent "Amen."

President Ronald Reagan heard more sales talk at a White House luncheon honouring the two fliers. Reagan reportedly diplayed interest; on the other hand, he reduced space spending by $640 million!

The agency's campaign tells us something about political impact upon U.S. space efforts. While Armstrong and Aldrin strode triumphantly on the Moon in 1969, Wernher von Braun urged Senate approval for a manned expedition to Mars, using Shuttles as building blocks. His plea fell on deaf ears.

Twleve years later NASA has decided to strike out for its second space station, a much less costly project. The agency sacrificed the 77-ton Skylab, still the largest spacecraft launched from Earth. Skylab cost $2 billion and made good use of Apollo equipment in 1973-74 when occupied by three astronaut crews.

Skylab took much less time and money than the Shuttle since it grew out of Apollo and was launched fully assembled by a two-stage Saturn V rocket. Typical of the profligate character of the space programme, whose fortunes wax and wane with succeeeding Congresses, the agency scrapped Saturn production lines and launch equipment. Lacking a powerful booster to hurl another station into orbit, NASA is thinking of hauling pieces into space where astronauts would gradually assemble the station.

At a cost of $45 million per Shuttle mission no one is prepared to stay how much a new version of Skylab will cost.

T 8

JAPAN'S NEW LAUNCHER

By Neville Kidger

On 11 February 1981 Japan's National Space Development Agency (NASDA) successfully placed a 640 kg satellite, Kiku 3, into a geostationary transfer orbit using the first of its N-2 launchers. The N-2 and its predecessor (the N-1) are closely based upon the US Delta launcher.

The initial orbital parameters of Kiku 3 (formerly the Engineering Test Satellite 4) were given by NASDA as: 36,259 km×258 km; inclination 28.6°. Kiku 3's mission was defined as testing the functions of the on-board systems of the satellite with regard to obtaining the necessary technological experience for the operation of large-scale heavy satellites. Additional programme objectives included monitoring the performance of the N-2-1 launcher. Launch was accomplished from the Tanegashima Space Centre.

The N-2 is capable of launching up to 350 kg (satellite plus apogee kick motor) into geostationary orbit, compared with the N-1's 130 kg capability to the same orbit.

Although closely based upon the US Delta launcher, the N series launchers exhibit several Japanese innovations. The N-1 used a Japanese-developed (with US technical assistance) second stage motor, the LE-3. The first stage motor for the N-1 and N-2 is the US designed MB-3, manufactured in Japan under licence from the US. The Japanese also construct the launch vehicles under the same terms.

The N-1 has three solid fuel strap-on boosters (SOBs) clustered around the base of the first stage. These US developed engines are also built under licence. These Castor 2 motors were developed by the Thiokol Corporation, who also provide the third stage of the launchers. Following the failure of the solid fuel third stage, provided by Thiokol, on the N-1-6 launch in February 1980, which resulted in the loss of the ECS-b satellite, NASDA has accelerated efforts to develop its own solid fuel kick motor. Completion target for the stage is the mid-1980s.

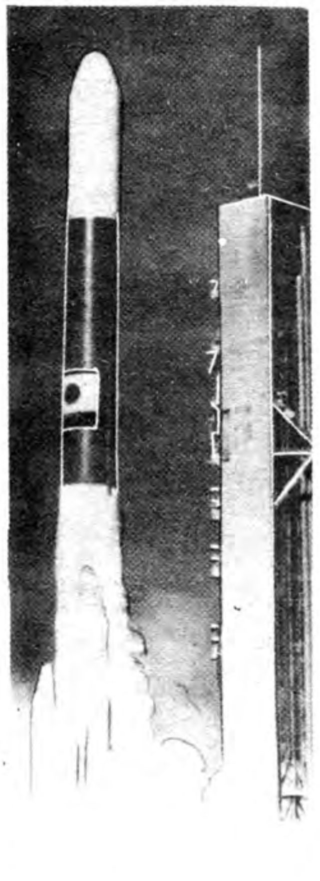
The N-2 features several major improvements in its design which enable it to launch heavier geostationary satellites. These include the increased number of SOBs (9 on the N-2 instead of 3 on the N-1), lengthening of the first stage and the introduction of a US motor for the second stage propulsion system (SSPS).

The first stage is manufactured from an aluminium alloy with a monococque structure with a machined isogrid lattice. It has been lengthened to accommodate a 23% increase in fuel over the N-1. N-2 first stage propellant weight is 82 tonnes. The MB-3 main motor comprises a main chamber and two vernier engines. The verniers provide roll control to the time of main engine cut-off and control pitch, roll and yaw thereafter until separation of the first and second stages. The MB-3 provides thrust for 269 seconds. At launch, six of the SOBs are ignited simultaneously and the remaining three are ignited after thrust tail-off of the MB-3. All of the SOBs burn for about 38 s and are jettisoned simultaneously 85 s after lift-off.

Trajectory and attitude control of the first stage is provided by the second stage Delta Inertial Guidance System (DIGS) *via*

		N-1	N-11	ETV-11
Size	Overall length (m)	32.57	35.36	Approx. 40
	Diameter (m)	2.44	2.44	2.44
	Total weight (t) [1]	90.4	134.7	Approx. 140
First stage	Propellant (oxidiser/fuel)	LOX/RJ-1	LOX/RJ-1	LOX/RJ-1
	Average thrust (t) (sea level) [2]	77	77	77
	Specific impulse (sec) (sea level) [2]	249	249	249
	Total/propellant weight (t)	70/66	86[3]/81	86/81
Strap-On Booster	Propellant (oxidiser/fuel)	Solid	Solid	Solid
	Average thrust (t) (sea level)	23.7×3	23.7×9	23.7×9
	Total/propellant weight (t)	4.5/3.75×3	4.5/3.75×9	4.5/3.75×9
Second stage	Propellant (oxidiser/fuel)	N_2O_4/A-50	N_2O_4/A-50	LOX/LH_2
	Average thrust (t) (vacuum)	5.4	4.4	10.0
	Specific impulse (sec) (vacuum)	285	315	440
	Total/propellant weight (t)	5.8[4]/4.7	6.75/5.80	10.2/8.4
Third stage	Propellant (oxidiser/fuel)	Solid	Solid	—
	Average thrust (t) (vacuum)	4.0 (TE-364-14)	6.8 (TE-364-4)	—
	Propellant weight (t)	0.56	1.05	—
Fairing	Diameter (m)	1.65	2.44	2.44
	Max. diameter of satellite accommodated (m)	1.44	Approx. 2	Approx. 2
Payload	Geostationary orbit [5]	130 kg	350 kg	—
	Circular orbit (1000 km/70°)	400 kg	1,100 kg	1,700 kg

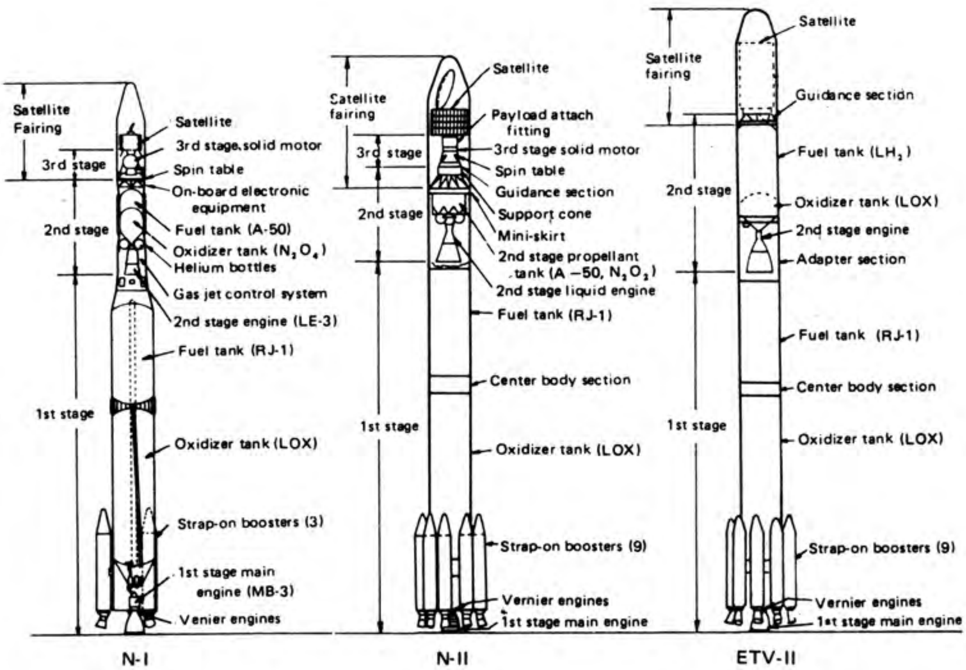
[1] Except the satellite and attach fitting.
[2] Main engine only (vernier engines not included).
[3] Including the interstage.
[4] Including the adapter section.
[5] Including apogee motor case.



Launch of the Japanese BSE comsat by a U.S. Delta.

Japan's New Launcher/contd

The Japanese N-1, N-11 and ETV-11 launchers. *NASDA*



commands to an electronic control package in the first stage which gimbals the MB-3.

The SSPS uses an Aerojet AJ10-118F engine which has a restart capability and a firing duration of a total of 420s. The SSPS is an integral type stainless steel construction with a maximum propellant weight of 6 tonnes. During SSPS operation pitch and yaw commands are provided by the gimbal actuation system through thrust vector control of the main engine. Roll commands are controlled by the cold nitrogen gas Attitude Control System (ACS). During periods of coasting flight all three control functions are provided by the ACS which is also used to settle the propellants prior to SSPS restart. All manoeuvring commands originate from the DIGS located in the guidance section atop the SSPS. DIGS is a strapped-down inertial guidance system with an inertial measurement unit and a computer, providing commands to separate control packages in the first and second stages.

Third stage of the N-2 consists of a solid fuel Thiokol TE-M-364-4 motor, supplied by the US company, a spin-table and a spacecraft attach fitting. The motor is constructed from polybutadiene with a total propellant weight of 1.1 tonnes providing thrust for 44s.

Before the launch of Kiku 3 (remembering the disaster which befell ECS-b) five members of NASDA's ruling council visited a Shinto shrine in Tokyo to pray for a successful launch. One commented that it was all they could do when they were not allowed to inspect the kick stage after receipt!

The N-2 will be used as the launch vehicle for several important Japanese satellites scheduled for launch up to 1986. The first operational launch of the N-2 is due in August 1981 when it should place a US-built Geostationary Meterological Satellite (GMS-2) into an orbital slot located at 140°E. Longitude.

Other geostationary satellites to be launched by the N-2 include two more medium communications satellites (CS-2a and b), two direct broadcast satellites (BS-2a and b) and AMES, the Aeronautical Maritime Engineering Satellite which will be used for communications experiments to small receiving terminals on ships and planes. In addition, the Maritime Observation Satellite, for Earth/Ocean resources observations, will be placed into a Sun-synchronous orbit inclined 99° at an altitude of 900 km circular.

Preliminary launch dates are: GMS-2 September 1981; CS-2a January/February 1983; CS-2b August/September 1983; MOS-1 (2-stage N-2) early 1985; BS-2a early 1984; BS-2b late 1985; AMES early 1986.

Japan will continue to develop improved launchers which, although still based upon the Delta, will continue to have Japanese equipment phased into them. The next launcher will be called the H-1A and will, by 1987 at the earliest, be capable of putting 550 kg into geostationary orbit. Before the first H-1A is flown, NASDA will launch an Engineering Test Vehicle in 1986 to verify the construction of the improved second stage which will incorporate a Japanese LOX/LH_2 stage called the LE-5. The N-1 and N-2 second stages currently use nitrogen tetroxide and Aerozine 50 as propellants.

A comprehensive digest of the Delta launcher, upon which the N-rocket is based, can be found in 'Delta Digest', *Spaceflight,* **21,** 10, pp. 413-418 (1979) by A. Wilson.

Meanwhile, Japan will not be neglecting her family of solid-fuel launchers. In order to launch the 'Planet A' Halley's comet probe in 1985, the Mu-3U launcher will be produced, capable of putting 700 kg into low Earth orbit. The comet version will have an added fourth stage motor.

Acknowledgement

The writer would like to thank the staff of the International Affairs Department of Japan's National Space Development Agency (NASDA) for information supplied in the preparation of this article. Major reference sources were: *NASDA 80-81* and *The Japanese Launch Vehicles Development,* which is the text of an address delivered by NASDA President Masao Yamanouchi to the 31st IAF meeting in Tokyo in September 1980.

THE SHUTTLE: SORTIE MISSIONS AND SPACELAB 1

Introduction

The Space Shuttle opens an exciting new avenue for space experimentation, the 'sortie mode'. Using this mode of operation, the Shuttle will serve in a single mission as a launch vehicle to deliver scientific equipment into low Earth orbit, as a manned laboratory for the conduct of scientific experiments, and as a re-entry vehicle to return equipment, data and specimens and samples back to the ground.

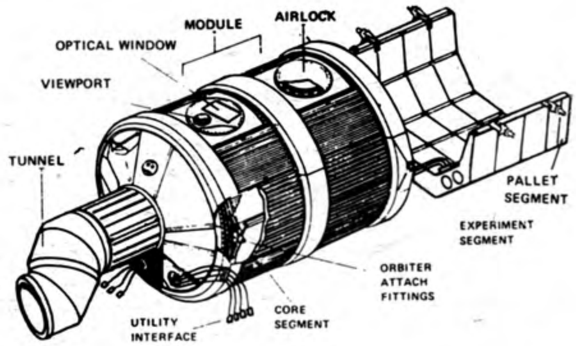
In its role as a launch vehicle, the Shuttle can carry to orbit up to 30,000 kg (65,000lb) of scientific equipment in the Orbiter's 18m (60ft) long by 4.6m (15ft) diameter payload bay. A crew of up to seven will be able to assist in the conduct of the scientific experiments. Such a crew might consist of three NASA career astronauts: a commander, a pilot and a mission specialist (serving primarily as a flight engineer) and up to four payload specialists who will operate the research equipment and conduct the investigations. The payload specialists may be selected from the general scientific and technical community and need not be members of the NASA astronaut corps.

A wide variety of laboratory support equipment can be carried in the Orbiter's cargo bay on Sortie missions. The most comprehensive of these is the Spacelab being provided by the European Space Agency (ESA). Two versions of the Spacelab are under development by ESA for use on the Shuttle.

One version provides a pressurised module which transforms a portion of the payload bay into a shirt-sleeve laboratory which can be entered directly from the Orbiter's cabin. A wide variety of equipment and specimens can be installed and stored in this module for use in orbit by the experimenters.

The second version of Spacelab is designed to allow instruments mounted on an open pallet to have direct exposure to the space environment once the payload bay doors are open. Both versions are modular and can be intermixed on the same mission. Spacelab also provides capabilities for data processing, experiment command and control, communications, environmental control and electrical power distribution.

When either version of the Spacelab is flown aboard the Shuttle, the entire mission will be dedicated to the operation of the instruments and experiments they support. A different type of mission, a mixed cargo mission, requires the use of less sophisticated support equipment.



Spacelab is made up from two basic elements: the pressured core segments and the pallets used for mounting external experiments Delivery of hardware for the first mission should take place this autumn in readiness for a flight two years hence, possibly aboard STS-10. NASA have had the Spacelab Engineering Model at the Cape since last year.

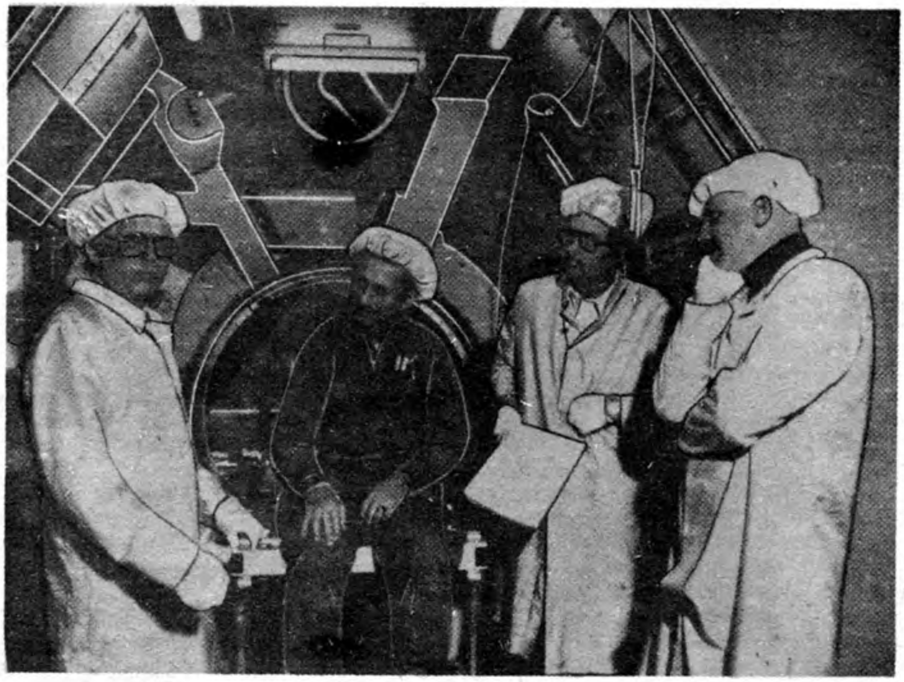
On mixed cargo Space Shuttle missions, the sortie portion of the mission will share the payload bay with satellites which will only utilise the launch vehicle capability of the Space Shuttle.

Such satellites, called free-flyers, will be taken to orbit in the Orbiter, deployed and left to go their own way. Once the free-flyers are delivered, the rest of the mission will be dedicated to the conduct of the sortie experiments. A variety of mixed cargo support equipment is under development to provide certain basic services for experiments which do not require support of the equipment provided by Spacelab.

Programme scope

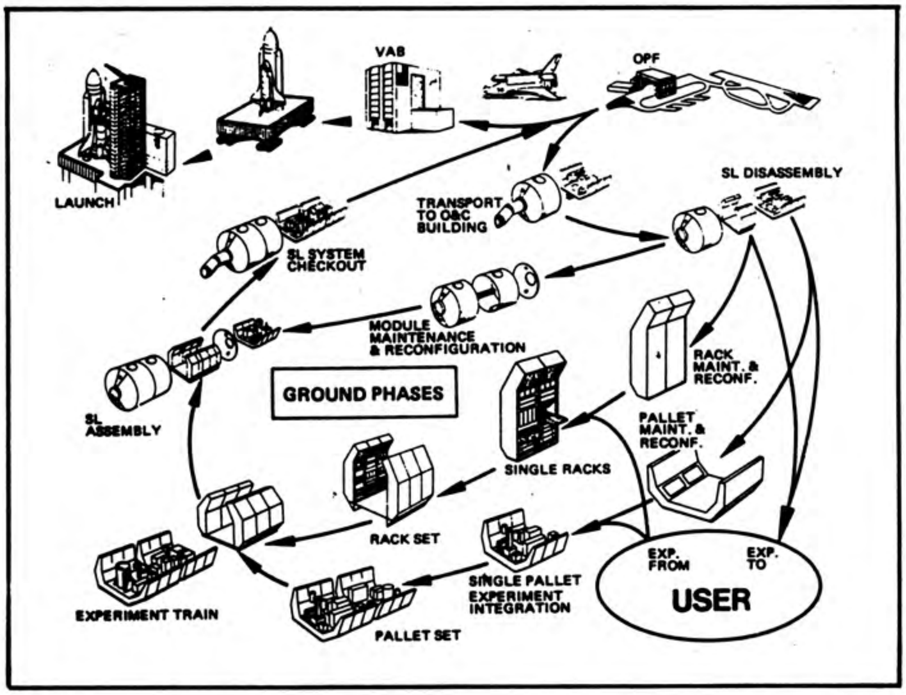
In support of the NASA Space Astronomy programme, sortie missions will be used to obtain the first high resolution ultra-violet images of galaxies and to conduct research programmes in infrared astronomy.

Sortie missions will allow extremely accurate measurements of the solar electromagnetic flux over the next decade and will be used to view the Sun with the highest spatial resolution ever



Owen Garriott, late of Skylab and now one of NASA'a Mission Spetialists for Spacelab 1 (the other is rookie Bob Parker) took part in a Flight Unit demonstration at ERNO in Germany. He and Ulf Merbold, one of the three European payload specialist candidates, went through simulated launch, experiment and landing profiles. Garriott is wearing the dark coverall in the picture.

ERNO



Flow diagram illustrating how a Spacelab configuration can be put together. The aim of Spacelab is to produce a *standard* craft for carrying experiments so that designers do not have to start anew for each flight.

achieved. The weight-carrying capability of the Shuttle will be used to carry massive instruments into orbit to detect cosmic rays before they interact with the Earth's atmosphere. Specialised instruments will be used to conduct active experiments in plasma physics using the Earth's magnetosphere as a geophysical laboratory.

Instruments will be used to look back at the Earth for a variety of purposes. Upper atmospheric constituents will be analysed to determine their composition, their quantities and their variation over the next decade, enabling us to better understand the impact of humans on the environment. Geological features hidden by dense vegetation will be identified in day or night and through all kinds of weather with a spaceborne radar.

The effects of weightlessness on humans and other living things will be studied. Studies will first focus on the physiological changes that may adversely affect the performance or health of humans during space flight or after their return from space. Subsequently, the focus will shift to the fundamental questions of space biology and explore the response of animals and plants to the absence of gravity.

Sortie missions will also be used to study how the gravity-free environment of orbital flight can be put to work in the processing of materials and chemicals. Early experiments in this discipline will encourage commercial applications of materials processing in space technology.

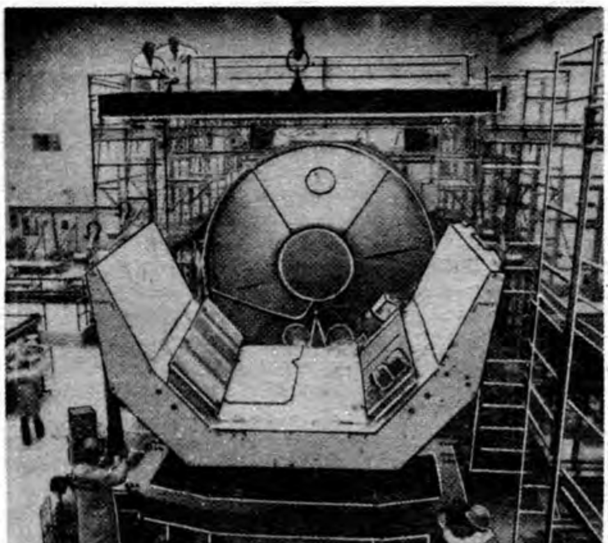
New technologies in space flight will also be tested on sortie missions. In-orbit tests of the deployment and control of large flexible space structures will pave the way in the development of the technology necessary for space platforms and large-scale instruments. Other technologies to be tested on sortie missions include thermal control techniques using heat pipes.

Programme participation

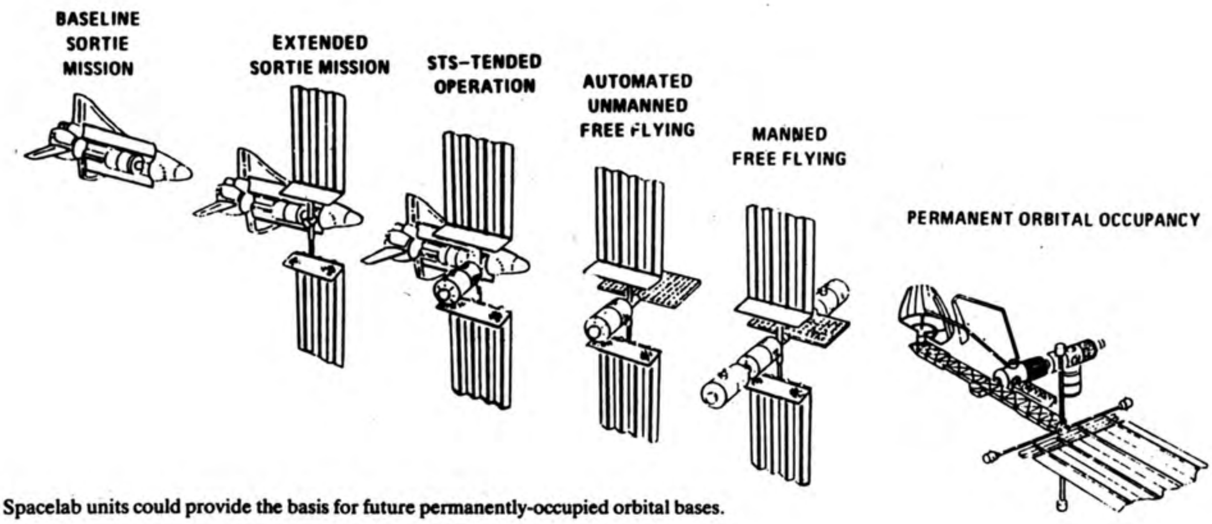
Most of the investigations planned for sortie missions were selected through the NASA Announcement of Opportunity procedure. This is a competitive process through which investigations are solicited in a manner similar to that used for contract proposals. The review and evaluation of proposals is accomplished by a peer review group from the appropriate scientific community. Competition responding to the six announcements of opportunity NASA has already issued for sortie missions has been very keen, with approximately 10 percent of those submitted being ultimately selected. Investigations selected by this process are required to put back all experiment data and results learned during the experiment in the public domain.

Programme content

The first scientific payload planned for flight on the Shuttle is Office of Space and Terrestrial Applications Mission (OSTA-1). Scheduled for launch on the second flight (STS-2), it was



Spacelab pallet and end cone of the pressurised section at ERNO.



Spacelab units could provide the basis for future permanently-occupied orbital bases.

specifically designed to operate in the constrained environment of the second Orbital Flight Test. Investigations on this mission will emphasise Earth observations. The second scientific payload, Office of Space Science Mission-1 (OSS-1), is scheduled for a later STS flight and will conduct investigations in many discipline areas, with a major emphasis on physics and astronomy.

Flight tests of two versions of Spacelab will be combined with scientific investigations in Spacelab missions 1 and 2 (SL-1 and SL-2). The SL-1 mission, a cooperative venture between NASA and ESA, will test Spacelab in the pressurised module configuration. A multidisciplinary set of investigations has been designed with a mixture of NASA and ESA sponsored scientific instruments.

The Spacelab-2 mission is a flight test of laboratory with the open pallet configuration. Twelve investigations will be conducted on this mission. Ten are provided by the United States and two by the United Kingdom. The experiments will perform research in several discipline areas including life sciences, plasma physics, astronomy, astrophysics, atmospheric research and space technology development.

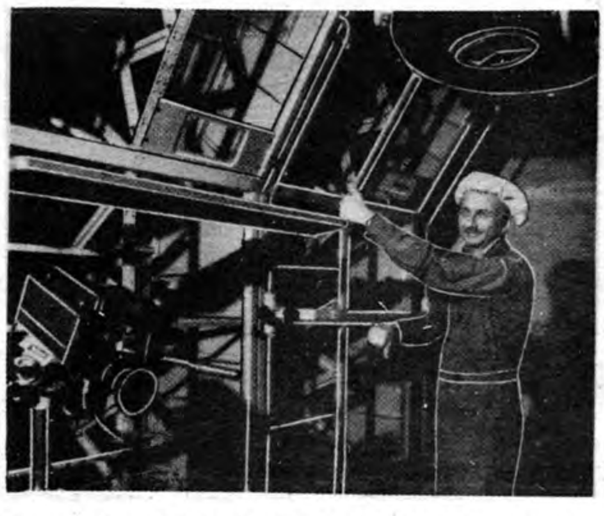
The first operational Spacelab mission, Spacelab 3, will be used to conduct investigations requiring extremely low acceleration levels and will focus on experiments in materials processing, space technology and life sciences. Additional experiments in astrophysics and environmental observations will also be conducted on SL-3.

A number of mixed cargo missions are under development for flight as early as can be accommodated by the Shuttle launch schedule. The Office of Aeronautics and Space Technology-1 (OAST-1) mission will occupy 1 m (3 ft) of the payload bay and conduct investigations in space technology. The major payload on this mission will demonstrate the deployment and retraction of a large solar array. This will also be used to study the dynamic response of a large structure to disturbances deliberately induced by the Orbiter's attitude control thrusters. The OSTA-2 mission and the Materials Processing System Mission-1 (MPS-1) will be used to conduct experiments in materials processing in space. The OSTA-2 mission is a cooperative venture with the German government.

Many of the experiments flown on OSTA-1 will be reflown on OSTA-3. The Large Format Camera, a stereoscopic high resolution instrument for observing the Earth's geophysical features, will also be flown on OSTA-3.

Future missions now being planned include Spacelab 4 and OSS-3. Spacelab 4 will mark the first exclusive flight of a biological laboratory for studying the effect of weightlessness on living organisms. Space astronomy in the ultraviolet wavelengths will be the major feature of OSS-3. The OSS-3 instruments will again be used on later missions to make synoptic observations of Halley's Comet from low Earth orbit. In the late 1980's NASA plans to fly a mixture of dedicated Spacelab missions and mixed cargo missions amounting to a total of six to eight sortie missions annually.

A major instrument now being developed is the solar optical telescope. Scheduled for flight in 1987, the telescope will achieve unequalled spatial resolution of solar features. It will have a number of focal plane instruments and will also be able to accommodate co-observing instruments (which provide their own telescopes), thus making it the most powerful solar observatory ever taken to orbit. Another major instrument planned for sortie missions is the Shuttle Infrared Telescope Facility (SIRTF). The focal plane of the facility will be cooled to −270°C (3 degrees above absolute zero) by liquid helium in order to minimise the background thermal emissions of the telescope and to achieve the extreme sensitivity possible with an instrument of this type. The facility will be used to study processes involved in the birth of new stars, in the study of the



Owen Garriott, a Mission Specialist for Spacelab 1, during a training session. Note the overhead hatch.

atmospheres of the outer planets and to determine the surface composition of asteroids.

There is a growing international interest in the use of sortie missions for scientific research. ESA, developers of Spacelab, is participating in the Spacelab 1 mission and has recently approved a major programme on microgravity research using it. The West German government has booked the first reimbursable dedicated Spacelab mission, D-1, for the conduct of a national research programme. The West Germans are also interested in the mixed cargo mode for sortie missions and have developed their own support systems. The Japanese government has begun negotiations with NASA regarding the possible booking of a portion of a Spacelab mission to conduct research in materials processing and life sciences. Similar discussions have also been conducted with the French.

Commercial interest in sortie missions is also materialising. NASA has established a Joint Endeavour programme to encourage commercial interest in areas such as space manufacturing. The basic principle of this programme is that NASA will share some of the risk in the initial stages of the activity with a commercial partner. For example, NASA may agree to provide transportation on the Shuttle if the commercial partner provides the apparatus and the experimental process. Once the feasibility of the process has been demonstrated, the commercial partner is obligated to fully reinburse NASA for all services including those initially provided. NASA has entered into a joint endeavour agreement with McDonnell Douglas. Several more are in negotiation.

Spacelab 1

At present, 72 separate investigations are planned for Spacelab 1. Investigations will be conducted in stratospheric and upper atmospheric physics, materials processing, space plasma physics, biology, medicine, astronomy, solar physics, Earth observations and lubrication technology.

Several different configurations of the Spacelab pressurised module and unpressurised pallets are possible but the configuration for the first Spacelab mission is a long module and one pallet.

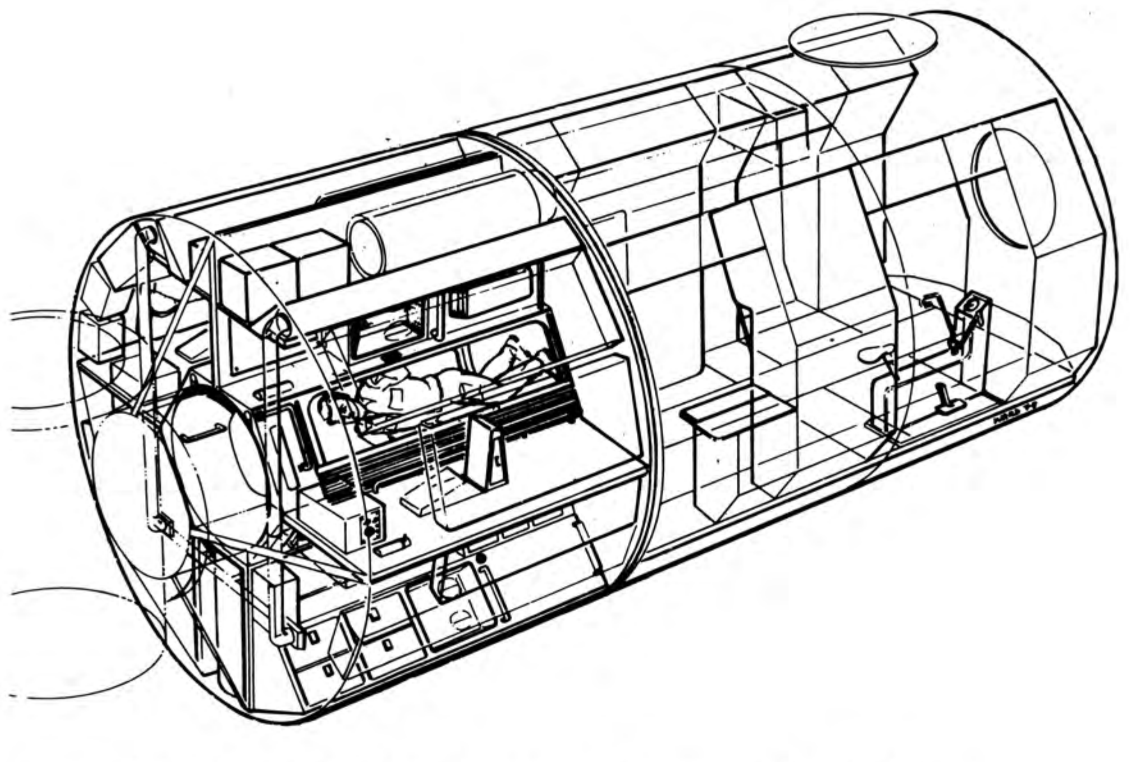
Spacelab 1 will be launched from the Kennedy Space Center. The mission duration is planned for seven days at an orbital altitude of 250 km (150 miles) and an inclination of 57 degrees. Following the flight, the Shuttle will make a runway landing at KSC. Launch is presently planned for late 1983.

Spacelab 1 will be the first Shuttle mission to actually fulfill the new promise of space — to carry into Earth orbit scientist crew members who are not professional astronauts. Six crew members will be needed to operate all of the science instruments, Spacelab systems and the Orbiter itself. Four of them — all scientists — are needed to operate the science instruments and to carry out orbital investigations. Two of these scientists (payload specialists) will be selected not by NASA but by scientists who have developed the instruments for the mission. For Spacelab 1, the two payload specialists will be chosen from among five research scientists now in training. One payload specialist will be a European, the other an American.

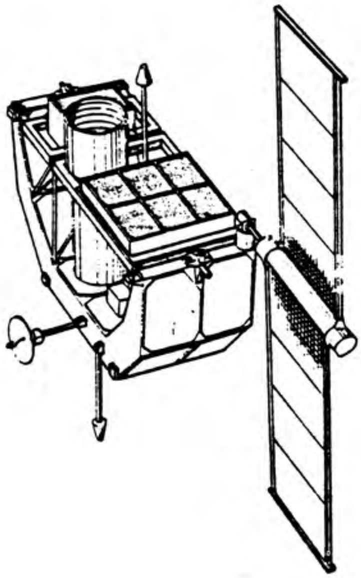
The two other science crew members are NASA mission specialists. They will be primarily responsible for the operation of Spacelab systems and will assist the payload specialists with the scientific investigations. The NASA mission specialists selected for this mission are Owen Garriott and Robert Parker. Two astronaut pilots, not yet selected, will operate the Orbiter.

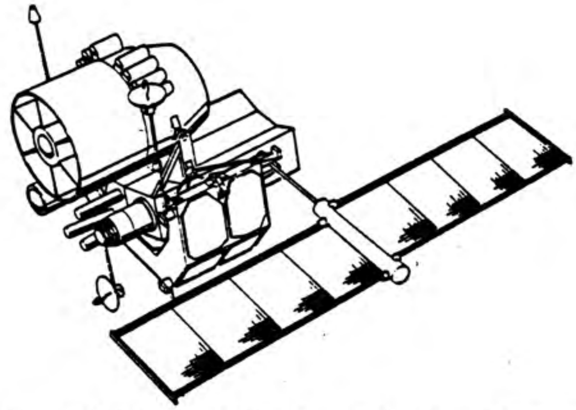
Science operations will be conducted continuously during the mission. Onboard, two crews of one payload specialist, one mission specialist and one astronaut pilot will alternate 12-hour shifts.

Science operations will follow a predetermined timeline established prior to the flight by ground flight support people



A concept design which uses Spacelab sections as habitation modules, somewhat reminiscent of a cramped Skylab.





The Shuttle and Spacelab offers the possibility of building "free-flyers". These are payloads carried into orbit for, say, astronomy missions but instead of making observations from the Orbiter's cargo bay they can be cast off into space. This way they are free from Shuttle contamination but it also means they have to provide their own power (as shown by the solar panels in the above examples). Since Spacelab pallets are designed specifically for mounting in the STS cargo bay there is a strong case for building "free-flyers" around pallet units.

and the investigators. In some cases, such as equipment failure or an unscheduled opportunity, Principal Investigator teams and Spacelab mission support personnel will direct or assist the onboard crew. The principal investigators and the Spacelab mission support teams operate out of the Payload Operations Control Center in Houston. Data obtained during the mission will be transmitted *via* the tracking and data relay satellite system and recorded by the Spacelab Data Processing Facility at Goddard Space Flight Center, Greenbelt, Md.

The Spacelab 1 mission experiments

Spacelab 1 is a multidiscipline mission incorporating five broad areas of investigation: atmospheric physics and Earth observations; space plasma physics; astronomy and solar physics; material sciences and technology; and life sciences.

Atmospheric physics and Earth observations, space plasma physics and solar physics investigators are utilising Spacelab 1 to better understand the origin and influence of turbulent forces that sweep past the Earth, causing visible auroral displays and disturbing radio broadcasts, civilian and military electronics, power distribution and satellite systems. Invisible magnetic storms can induce electric currents in long power-transmission lines, affect power station transformers and even cause power blackouts.

Disturbances in nearby space are consequences of the reactions in Earth's neighbourhood to the violent behaviour of the Sun. The past 20 years of space observations have led to a quiet but remarkable revolution in concepts of the Sun-Earth system. No longer is Earth visualised as simply a body traveling through a vacuum round the Sun and being warmed to life by its visible emissions.

Rather, data from spacecraft show that Earth is plowing through an energy-laden flood from the Sun — magnetic fields, energetic charged particles, radiations throughout the electromagnetic spectrum and plasmas flowing at speeds up to 1,000 km per second (2.2 million miles per hour).

Collisions with Earth's magnetic envelope create a dynamic environment reaching far beyond previous environmental concepts. This region extends to millions of kilometres around the Earth and contains the atmosphere, the ionosphere, the magnetosphere and the near-Earth interplanetary medium.

This region is an integrated, strongly interactive system throughout which energy is continuously being generated, stored, transformed and released. The coordinated atmospheric physics, plasma physics and solar physics investigations will greatly contribute to our understanding of this region.

The solar investigations will measure the total energy output of the Sun with three different, cross-calibrated instruments. The goal of these investigations is to determine quantitatively, with state-of-the-art accuracy, any variations in the solar energy output. Such information is important not only in studies of physical processes on the Sun but also for studies of the effects of these variations on the Earth.

The atmospheric physics investigators will perform studies of the Earth's environment through surveys of temperature, composition and motion of the atmosphere. A broad spectral range from ultraviolet to infrared will be used to study the emissions or absorptions of light by the atmosphere. From these studies, the sources, flow patterns, transport and decay mechanisms of atmospheric molecular constituents will be determined. The Earth observations investigations, the metric camera and the microwave scatterometer (a radar), will be used to demonstrate the capability of these advanced measuring systems for making topographic and thematic maps from high resolution photographs and active remote sensing (radar). The radar equipment will be the first European active remote sensing device to be flown in space.

The space plasma physics investigators will perform a variety of coordinated experiments to understand the basic physical processes which occur in this magnetised plasma environment. Spacelab provides a unique opportunity to conduct both passive (observing naturally occurring phenomena) and active (artificial stimulation of the plasma environment) experiments. Active experiments are carried out by injecting negatively charged particles (electrons) and positively charged particles (ions) into the ambient plasma and observing the resulting interaction with an array of diagnostic instruments.

The technique is similar, in concept, to the use of radioactive tracers in medical research. Numerous collaborative studies are being planned in which data taken from several investigations will be pooled and analysed.

A cosmic ray experiment will measure the energy and number distribution of cosmic ray nuclei. This investigation will provide information on the source, acceleration and propagation of particles in the Solar System. These investigations provide clues to the very origin of the Universe.

The astronomy investigations will study astronomical sources in the ultraviolet and X-ray wavelengths. These

wavelengths are not observable on Earth due to absorption by the ionosphere or ozone layer. Surveys of the celestial sphere and detailed studies of specific objects will be performed with the UV and X-ray instruments.

The material sciences and technology investigations will demonstrate the capability of Spacelab as a technological development and test facility. The investigations in this group cover a variety of fields in space material sciences (also called space processing). All the experiments have a common bond — the physical mechanisms involved are adversely affected on Earth by gravity. These investigations take advantage of the microgravity conditions to perform studies in crystal growth, metallurgy, fluid physics, glass and ceramics technology and electrophoretic separation — a technique widely used for pharmaceuticals which separates different, complex, molecular solutions by their electric potential.

The life sciences investigations are concerned with the effects of the space environment (microgravity and high energy radiation) on human physiology and on the growth, development and organisation of living systems. Investigations of human physiology will study effects related to the absence of gravity such as body fluid redistribution, reductions in circulating red blood cell mass, immunological changes, deviations from normal mineral metabolism and others. Some of these effects have been observed on astronauts in previous space flights. A special category of vestibular function investigations (motion sensing and balance maintenance) will probe the interactions between man's otolith/vestibular system and brain, leading to a potential understanding of the causes of space motion sickness.

Other studies will be concerned with how plants know which way is 'up' and whether circadian rhythms in some biological systems are governed by internal or external (environmental) mechanisms.

There are 35 different major instruments and an assortment of supporting instruments on Spacelab 1. Of the 35, four are multi-user facilities, three of which are supplied by ESA and one by NASA.

These facilities are designed for continuous reuse by many different investigators in a given discipline (e.g., material sciences) and will be flown on many missions. Like the multi-user facilities, many of the other major instruments are designed and intended for reuse on later missions.

Twenty-four of the 35 instruments are located on the open

Owen Garriott, right, during Spacelab tests. *ERNO*

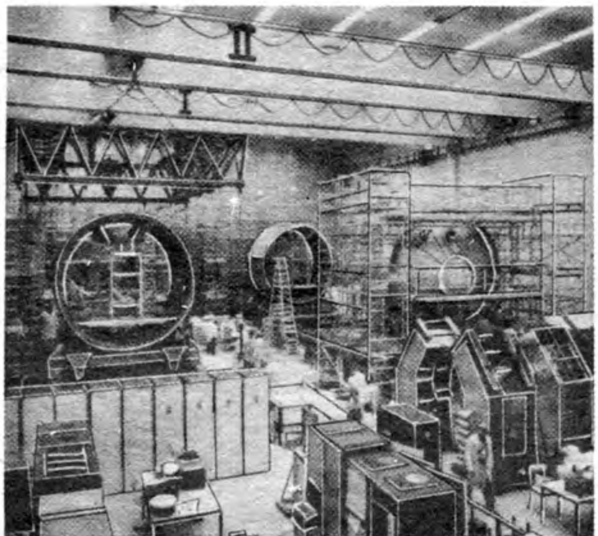
pallet and 10 in the habitable module, with one having components both on the pallet and in the module. Many of the pallet-mounted instruments are controlled from within the pressurised module by the onboard crew.

Since this will be the initial Spacelab flight, important mission objectives are the verification of the Spacelab hardware and systems. A key consideration for the choice of investigations scheduled for this mission was for experiments which used most of the capabilities of the Spacelab subsystems. In this manner, Spacelab and its systems will receive a thorough and meaningful test of their actual capabilities. Spacelab 3 is the first mission in which the Spacelab is considered operational.

Specific tests are planned to verify the Spacelab structure, the environment control system, the choice of materials used in constructing Spacelab and its subsystems, and the habitability or crew-support features such as work station adequacy, stowage provisions and noise characteristics. In addition, various measurements will be made of the environment both inside and outside of Spacelab.

To obtain this data, maximum use of existing Orbiter/Spacelab operational instrumentation will be made. Experiment data will also be used to verify the performance of Spacelab. In addition, specific verification flight instrumentation will be added as necessary.

In demonstrating the capability of the Spacelab system to conduct scientific investigations across a broad range of disciplines, Spacelab 1 will acquire fundamentally important knowledge of the physical processes which control our environment.



Spacelab units under construction. At *right* is an end cone, while *right foreground* are the internal equipment racks. *ERNO*

Payload specialists

An Investigators Working Group (IWG), composed of Spacelab 1 experimenters, has been established to conduct these investigations. The chairman of the Working Group, who also serves as Spacelab 1 mission scientist, is Dr. Charles R. Chappell, Chief of Solar Terrestrial Physics Division, Space Sciences Laboratory at Marshall Space Flight Center.

Two Americans and three Europeans have been selected by fellow scientists in the IWG to make up the Spacelab 1 Payload Specialist crew. These are: Dr. Michael L. Lampton, University of California, Berkeley; Dr. Byron K. Lichtenberg, Massachusetts Institute of Technology; Dr. Ulf Merbold, German, Max-Planck Institute, Stuttgart; Dr. Claude Nicollier, Swiss, European Space Technology Centre; and Dr. Wubbo Ockels, Dutch, Groningen University, Netherlands.

At a designated time in the training cycle, two of the five payload specialists, one ESA and one NASA, will be selected to actually fly aboard the mission and the others will be assigned Earth-based duties. After that selection is made, the flight payload specialists will concentrate more on procedures and flight mission operations. The goal is to reduce the payload specialists training time for later missions to about 12 months. This would reduce the time that the scientist must spend away from normal research activities.

SPACE REPORT

VENUS' SURFACE TEMPERATURE

Using NASA's Pioneer-Venus spacecraft data, it now appears likely that the searing 482°C (900°F) surface temperature of Venus is due to an atmospheric greenhouse effect. Until now the Venus greenhouse effect has been largely a theory.

The work is important for us on Earth in understanding possible adverse effects on agriculture resulting from long-term use of fossil fuels.

The greenhouse effect means that the surface temperature is raised when energy (sunlight) easily passes through Venus' atmosphere to the surface but has difficulty escaping after conversion to longer-wave heat radiation, and is held in by the atmosphere (the same principle provides much of the heat for nursery greenhouses on Earth).

Calculations using Pioneer measurements of atmospheric composition, temperature profiles and radiative heating predicted Venus' surface temperature "very precisely" according to Dr. James Pollack of NASA's Ames Research Center, head of the Pioneer-Venus radiative heating team. The calculations predict not only Venus' surface temperature, but agree with temperatures measured at various altitudes above the surface by the four Pioneer Venus atmosphere probe craft.

The accuracy of the Venus atmospheric heat balance predictions increases the confidence of scientists for making similar predictions for the Earth, including the effect on Earth's atmospheric heat budget caused by the burning of fossil fuels.

The main atmospheric ingredient trapping Venus' heat is carbon dioxide. Eighty years of burning fossil fuels on Earth has increased atmospheric carbon dioxide by 15% - and predictions of increased burning of fossil fuels (e.g. coal and oil) suggest that carbon dioxide in Earth's atmosphere could double in 50 years. This could raise the average temperature by up to 4 °C (7 °F)

This is small compared to the inferno of Venus' surface. Nonetheless, such a temperature increase could well cause "incredible havoc," says Dr. Pollack - during the most severe phases of the Earth's ice ages the average drop in atmospheric temperature was only 7 °C (15 °F). Examples of major weather changes resulting from a 1 to 3.5°C (2 to 7°F) change in average temperatures might include catastrophic differences in rainfall in marginal agricultural areas such as wheat-growing regions of Canada, the USSR and the United States. Such temperature changes might also melt a small but important portion of the polar ice caps, enough to raise ocean levels and cause permanent flooding in major coastal cities.

Having calculated atmospheric heating for Venus (which is an extreme case), calculations of carbon dioxide effects on Earth's atmospheric heat budget should be much easier. While these predictions may be overstated, Pollack points out, we should determine whether they are or not, and Venus greenhouse data will certainly help us to do this.

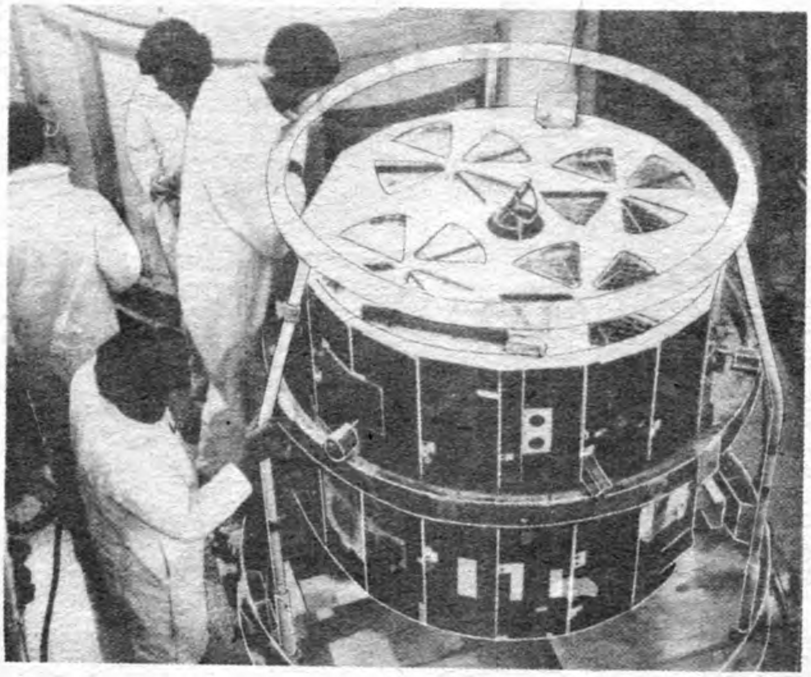
Only half of the carbon dioxide so far sent into the Earth's atmosphere by fossil-fuel burning has stayed there. the rest has apparently been absorbed into the oceans. However, ocean absorption effects have been included in the calculations of carbon dioxide doubling.

Venus' surface temperature of 482 °C (900 °F) is remarkable. The planet is only 30% closer to the Sun than Earth and, with a relatively thin atmosphere like ours, its surface temperatures might be expected to be around a warm but habitable 38 °C (100 °F). Earth's existing greenhouse effect heats up the surface some 36 °C (55 °F), while Venus' surface temperature is wrenched upward by 425 °C (800 °F). This happens despite the

NEW SKY SURVEY

The major part of the first optical survey of the southern sky has been completed by astronomers at the European Southern Observatory in Chile and the 48 in. UK Schmidt Telescope at Siding Spring in Australia. Of the 1000 highly-detailed photographic plates, about 600 are being used to produce the 'Atlas of the Southern Sky'.

Until recently, the southern hemisphere has been poorly served by large telecopes and is not so well covered as the northern regions.



The Atmosphere Explorer-5 (AE-5) reentered the atmosphere on 10 June, after 31,268 orbits and more than 5½ years of service.

The last signal was received from the spacecraft over Hawaii before descending across the Pacific Ocean, Central America and into the Atlantic Ocean. No signal was received when it was due over Ascension Island. The North American Air Defense Command (NORAD) later confirmed that AE-5 reentered at 9:57 a.m. EDT in the Caribbean, east of Nicaragua.

The 1587 lb (720 kg) satellite was launched by Delta on 20 November 1975 into an eccentric orbit, with its perigee dipping into the upper layers of the atmosphere. An onboard propulsion system was then used to prevent early orbital decay so that AE-5 could continue making measurements in this otherwise inaccessible region.

It was also the first satellite to use a central computer and data base which meant that all data was immediately accessible to the investigators at their own facilities.

Space Report/contd.

YOUNG AT HEART

During his visit to Britain in mid-June, Shuttle commander John Young paid a vist to Prime Minster Margaret Thatcher at 10 Downing St. Young, who says he is hoping for another flight, presented a plaque signed by the STS-1 astronauts and President Reagan. The Union Jack flew aboard *Columbia* during the first mission.

During a subsequent press conference at the U.S. Embassy, Young described Mrs. Thatcher as "a real sharp lady".

Left to right: Mrs. Young, John Young, Mrs. Thatcher and U.S. Ambassador John Louis.

U.S. Embassy

fact that Venus currently absorbs less solar energy than the Earth (the highly reflective clouds bounce back much of its incoming solar energy to space).

The Pioneer team has established the role and amount of heat trapping by the various gasses and particles in Venus' atmosphere. These include carbon dioxide, water vapour, sulphur dioxide and various types of cloud particles. Finally, Venus' planet-wrapping haze layer provides a 'cap' to the greenhouse, explaining the last 12 to 15 °C (25 to 30 °F) of temperature. Water vapour quantities reported by the Soviet Venera craft were used in the greenhouse calculations instead of the Pioneer measurements because they fit well with the rest of the data. The amount of water vapour finally decided on was much less than had been thought required to produce the planetary greenhouse effect. The team found that the remaining heat expected to be absorbed by water vapour was, instead, absorbed by sulphur dioxide and the heavy clouds.

The amounts of heat taken up by the various key absorbers in the Venusian atmosphere are: carbon dioxide, 55%; water vapour, 25%; clouds and haze, 15%; and sulphur dioxide, 5%. Certain of the Pioneer Venus atmosphere composition measurements were critical to the calculations. These were: carbon dioxide, 96% of the total atmosphere; water vapour, about 50 parts per million (ppm) in the lower atmosphere (Venera data); sulphur dioxide, about 200 ppm in the lower atmosphere. Cloud depths used were: 30 km (19 mi), and haze layer depth 12.5 km (7.8 mi).

ANOTHER ANTI-SATELLITE TEST

One of the earliest Soviet flights of 1981 involved a test of a satellite interception vehicle. On 2 February, Cosmos 1243 passed within a few kilometres of its target, Cosmos 1241, which had been in orbit for just under two weeks, writes Robert Christy.

Cosmos 1241 was placed into a 976×1010 km orbit, with a period of 104.98 minutes and an inclination of 65.82 degrees to the equator. The launching vehicle was a C-1, and it came out of the Plesetsk cosmodrome on January 21.

On 2 February, at approximately 0221 GMT, Cosmos 1243 was launched from Tyuratam by an F-1 vehicle. It attained an orbit of 296×1015 km, 97.85 minutes, 65.82 degrees, leaving an intermediate stage behind in a 59×306 km, 88.16 minute orbit, which decayed after less than one revolution. The chosen orbit was such that it passed within 15 km of Cosmos 1241 at 0539 GMT as it approached apogee at the end of its second orbit. The height was 1010 km, and the two craft were at latitude 59 degrees north, longitude 32 degrees east, near Leningrad. At about this time, Cosmos 1243 manoeuvred, so the miss distance may well have been less than that quoted above. The manoeuvre put the interceptor into a trajectory which caused it to re-enter the Earth's atmosphere; NORAD issued a decay note for the same day.

The interception was similar to that of Cosmos 967 by Cosmos 1009 in May 1978. On that occasion, too, the interception came at the end of the second orbit and the interceptor re-entered immediately. The interception of Cosmos 1171 by Cosmos 1174 during April 1980 started off in a similar way but on that occasion, the interceptor got no closer than about 60 km. However, later manoeuvres produced two more close passes, the second was to within 20 km (see *Spaceflight*, **22**, 9-10, p. 326, September-October 1980).

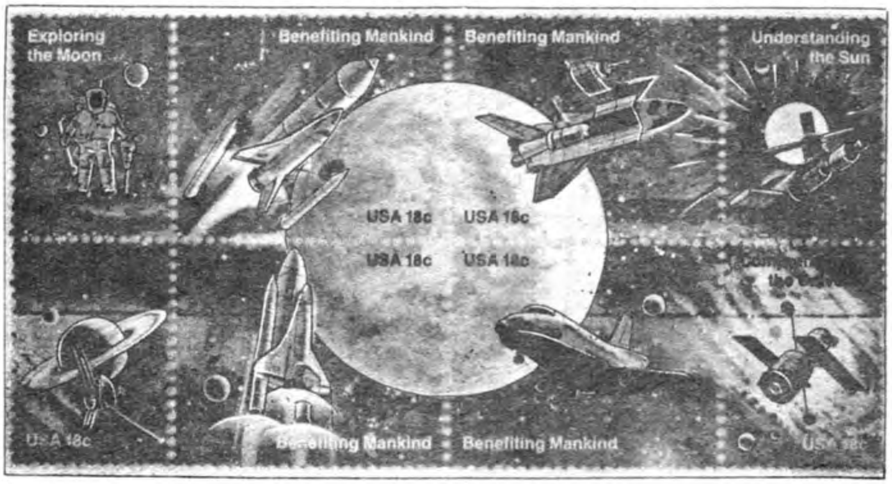
The Cosmos 1174/1171 interception apparently involved also the microthruster-controlled Cosmos 1167. At the time of the first two close passes, it was within 5000 km, and on the

'STARLAB' SPACE TELESCOPE

The new Starlab space observatory under consideration by NASA may carry a recently-developed low-light system which would allow individual photons to be registered from distant objects such as stars and galaxies.

A photon hits a photoelectric surface releasing a number of electrons in response which, in turn, hit a phosphor surface to release a new shower of photons - perhaps as many as 10 million. Further stages and processing produce a 2-dimensional picture with a sensitivity some 10,000 times greater than ordinary film.

The team at the Australian National University in Canberra hopes to produce such a device with a sensitive area six inches in diameter.



NEW SPACE STAMPS

A block of eight US space stamps, designed by well-known artist Robert McCall, was issued on 21 May. The centre stamps show the main phases of a Shuttle mission while the outer depict Apollo, Skylab, the Space Telescope and Voyager, all set against a pale blue background.

occasion of the third interception of 1174 by 1171, it was directly below the event, presumably as an observer. There is no evidence to suggest that any other satellites were involved in the latest test, although Cosmos 1167 was still in orbit along with its later companion Cosmos 1220. During the 1980 test, Cosmos 1167's orbit was in the same plane as the target and interceptor, on this occasion its (and Cosmos 1220's) orbit was nearly 180 degrees away in longitude.

US press reports at the time of Cosmos 1174 indicated that it and Cosmos 1009 represented a version of the USSR's interceptor which uses optical-thermal detection of the target rather than radar. They were also said to carry (possibly) a laser as the method of disabling the target. The flight of Cosmos 1174 was reported as being a failure because the close interception did not take place on the second orbit, but the interaction between it and Cosmos 1167 suggests this may not necessarily be true.

SHUTTLE MAIN ENGINES

Following the successful launch of the *Columbia* in April, emphasis at Rocketdyne, the builders, is on full power level (FPL) development of the engine.

The Orbiter's three main engines were certified in January 1981 for the STS-1 launch and other early Shuttle flights. Full power level, 109 percent of the engine's nominal operation, is required for later missions.

A two-year programme of testing is planned to certify the engine for 10,000 seconds, (the equivalent of approximately nine Shuttle missions) at full power operation by early 1983. Three engines will initially be used in the programme to demonstrate operating capability at the higher power level.

In a London press conference on 19 June, Columbia commander John Young said that lift-off was very "soft", like a fast elevator. Before the flight he thought that it would be like being "hit on the back of the head with a hammer". Noise levels in the cabin were also less than on Apollo-Saturn V launches.

Single engine test stands A-1 and A-2 at NASA's National Space Technology Laboratories in Mississippi, will be used for testing of Engine's 2108 and 0204 respectively. Engine 2108, after re-assembly following incorporation of design modifications to extend its FPL life capability, was installed in Test Stand A-1 in late April. Engine 0204 began FPL testing on Test Stand A-2 in early April.

Engine 0110 is undergoing tests on Stand A-3 at Rocketdyne Division's test site in the Santa Susana Mountains in California.

With the 23 March completion of its 109 per cent abort mission test series, Engine 0008 was designated as a rated power level stand-by engine. During four tests conducted in March, the engine was operated at 107 percent of rated power for 360 seconds during each of two tests and at 109 percent of rated power for 360 seconds during each of the other two tests.

BULGARIAN SATELLITES

The Soviet Union is to put into orbit two satellites carrying Bulgarian-built scientific apparatus. The launches are linked to the 1300th anniversary of the founding of the Bulgarian state and are to be carried out under the Intercosmos programme.

The ionosphere - a layer of charged particles beginning at about 25 mi altitude and extending upwards for several hundred miles - is well known for its radiowave-reflecting properties. Before comsats it was the only convenient way to transmit over long distances. We all know that it is disturbed during solar storms as high-energy particles pour in and low-frequency transmitters on Earth can themselves cause problems. The theory is that electrons in the magnetosphere can be simulated by these waves, descending into the ionosphere and destroying its mirror-like properties. This satellite instrument will watch for X-rays and air glow effects as electrons hit the atmosphere while transmitters on the ground are systematically turned on and off in an attempt to prove a cause-and-effect relationship.

writes Robert Christy.

The main satellite body in each case will be the standard Meteor type. The first Bulgaria-1300 vehicle will be equipped with purely Bulgarian apparatus, and its task will be to study the ionosphere and the reaction between the ionosphere and the magnetosphere. The twelve items of scientific equipment are to be supplied by the Bulgarian Academy of Sciences' Central Laboratory for Space Research. The second satellite will carry both Bulgarian and Soviet equipment and sensors; its task will be to study the natural and reflected radiation from the Earth in the infra-red band of the spectrum and to produce cloud cover and Earth surface images. Parallel observations will be made from aircraft and from Earth based observing stations.

One of the Bulgarian contributions is to be a data processing computer to control the experiments and to prepare data for transmission to Earth stations in Bulgaria, from where it will be forwarded to scientific institutions in both countries.

The first satellite is due for launch during the second half of 1981 into a 900 km, near-circular, near-polar orbit. In addition to the active scientific apparatus, it will carry a set of laser reflectors so it can be used passively in geodetic experiments. The Intercosmos countries are arranging a special campaign of visual, laser and photographic observations and have invited optical tracking stations around the world to join in. Co-ordination of the optical programme is the responsibility of the Bulgarian Central Laboratory for Geodesy.

The objectives of the optical observations are to obtain more accurate positional fixes on the observing stations using laser tracking to check the satellite's own navigation system against observed data, and to investigate the influence of the atmosphere on the orbital parameters.

Launch and orbital information on the second vehicle have not yet been released, but the most suitable orbit for the experiments described would be a retrograde, Sun-synchronous one similar to that currently used by the Meteor series of satellites. This would imply a Tyuratam launch.

JAPANESE SPACE PROCESSING

Japan's National Space Development Agency (NASDA) has begun a series of materials processing experiments using small sounding rockets which it is hoped will lead to that country's first manned spaceflight experience aboard the US Space Shuttle in the mid-1980s, writes Neville Kidger.

Using the TT-500A sounding rocket series NASDA plans two flights per year of materials processing payloads which will experience microgravitational forces (less than 10^{-4}g for up to 7 minutes duration.

The experiment series will involve melting and crystal growth and will provide the experimental basis for the actual Shuttle flight. The series will also provide testing technology for the payload recovery system.

The first flight, conducted on 14 September 1980, was a test of the functional ability of the TT-500A recovery system. The nose cone, which contains the materials smelting furnace, was recovered. Smaller MT-135P meteorological rockets were fired from the same Tanegashima Space Centre launch site as the TT-500A one day before and one day after the flight to obtain meteorological data (such as wind direction, velocity, temperature, etc.) over the space centre at the time of the TT-500 launching.

The second TT-500A flight, on 15 January 1981, was successful until splashdown of the payload some 500 km downrange of Tanegashima. At that point radio beacon signals ceased and search parties were unable to locate the payload. The payload comprised a metallic compounds processing experiment (Ni-TiC whisker). Flight number 3, due for launch in August-September 1981 will process a Si-As-Te amorphous compound.

The Space Shuttle flight with Japanese materials science experiments is planned as early as possible after the start of Japanese Fiscal Year 1985 and will probably take place in early 1986.

ESA/NORWAY AGREEMENT

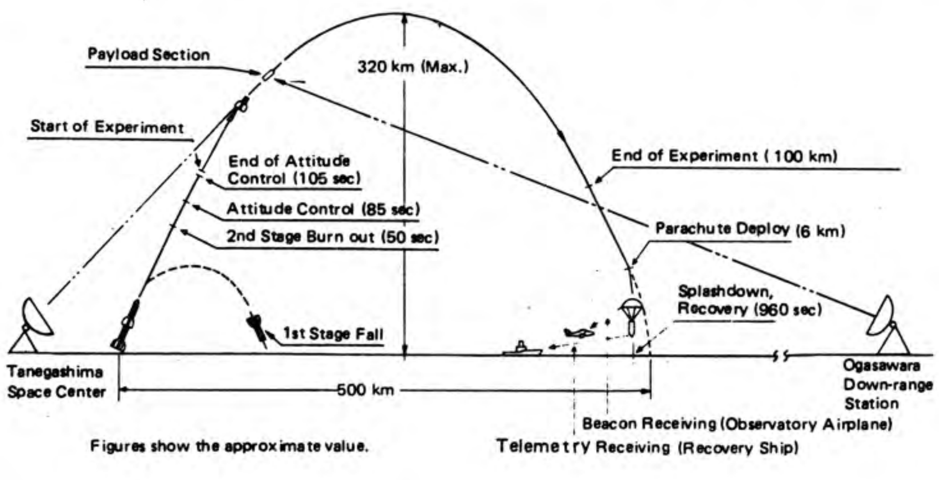
An agreement was signed at the ESA headquarters in Paris on 2 April by Mr Odd Gothe, Deputy Secretary General of the Norwegian Ministry of Industry, subject to approval by the Parliament of Norway, and by Mr Erik Quistgaard, Director General of ESA. Under the terms of this Agreement, Norway will have associate membership status for a period of five years, during which time it may consider acceding to the Convention of 30 May 1975 and thus become a full member.

As an associate member, Norway will be able to participate in the Earthnet programme and in general studies for future projects.

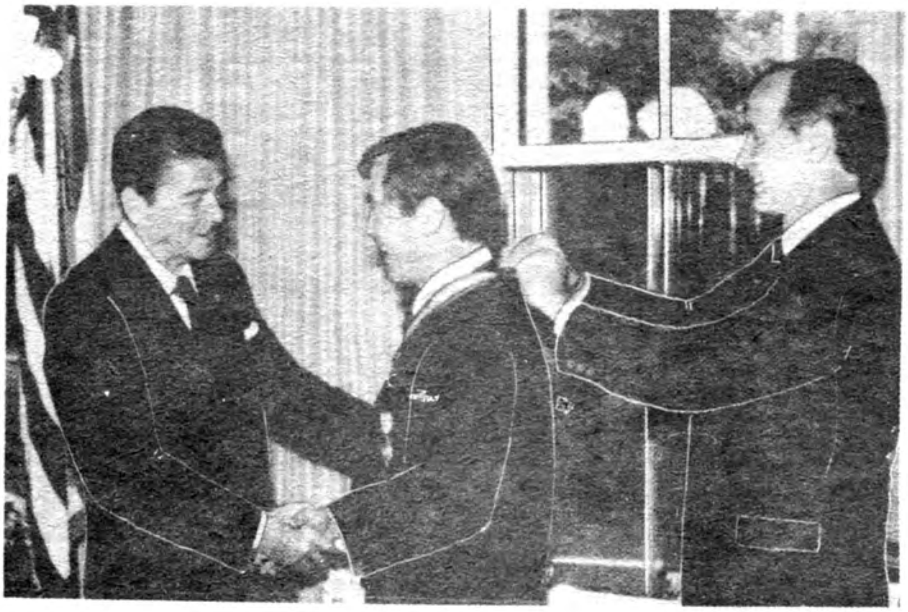
RADIATION DISCOVERY

A group of Soviet scientists from Moscow University and the Lebedev Physics Institute have discovered a new phenomenon: the downward flow of particles from the Earth's radiation belts over the negative magnetic anomalies.

Studying the data sent back by satellites, writes Julian

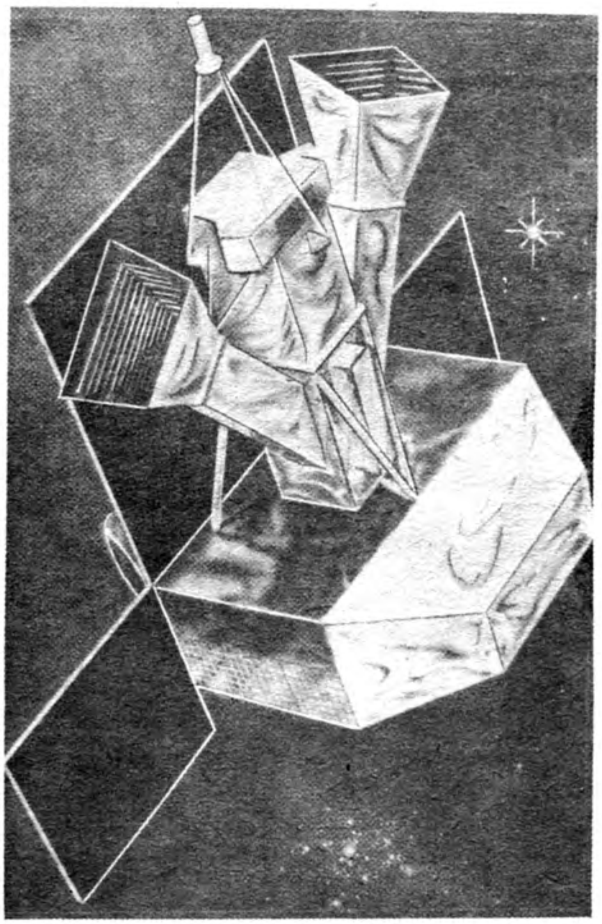


Flight profile of the Japanese TT-500A materials processing sounding rockets.
NASDA



President Reagan *(left)* and Vice-President Bush *(right)* present STS-1 Commander John Young with the Congressional Medal of Honour during the crew's visit to the White House on 19 May.

Popescu, the scientists have discovered regions of intense radiation at heights of 200 to 300 km. The phenomenon was observed in the atmosphere over the South Atlantic and the Antarctic geomagnetic anomalies.



Hipparcos, ESA's astrometry satellite. *ESTEC*

HIPPARCOS PROPOSALS

ESA has asked for observing proposals for its Hipparcos astrometric satellite to be submitted by October 1982 at the latest. The satellite, due for launch in 1986, will measure the positions, parallaxes and proper motions of some 100,000 stars and star-like objects over its mission life of 2½ years. Planning is so complex that the observing programme has to be simulated and finalised *before* launch, whereas other spaceborne observations can accept new observing schedules in flight.

INFRA-RED SPECTROSCOPY

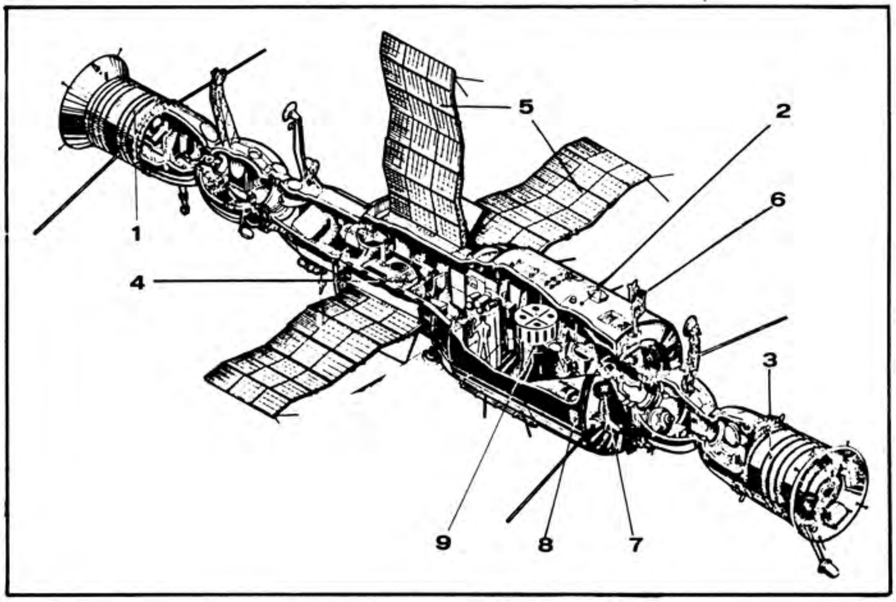
In mid-November 1980, the Soviet press reported that a group of scientists led by Academician Prokhorov had successfully used an instrument called carcinotron (literally 'shaped like a crab' or 'circle-plus-particle') in their research on sub-millimetric (i.e. infra-red) spectroscopy. The resonant frequencies of protein molecules are found in this waveband and a whole range of substances also show up there, writes Julian Popescu. Moreover, according to Academician Prohorov, many physical phenomena in solids, liquids and gasses occur in the sub-millimetric world. A few metals at very low temperatures have been found to be electrically superconductive and the recently discovered energy gaps which determine this phenomenon have specific values which relate to this waveband.

Infra-red spectroscopy was investigated in the Salyut-6 space lab and is now being used to create especially pure fibres. Technical development has already been carried out by research scientists in Gorkiy on the banks of the Volga.

ERRATUM

In the article on Halley's comet on pp. 212-213 of the last issue, the sentence "In 1695 Halley began the task of determining the orbits of 24 comets for which observational material was not available" should have ended with "....was *then* available." Even Halley was not brilliant enough to calculate their orbits without any data!

The Salyut 6 station with two Soyuz ferry craft attatched. Key: 1 and 3 - Soyuz craft; 2 - main compartment; 4 - controls; 5 - solar panels; 6 - docking antennae; 7 - orbit correction motor; 8 - altitude control motors; 9 - scientific equipment.



Technology Experiments

In the field of technology the Dniepers continued and expanded upon the basic series of experiments begun when the Taimirs (Romanenko and Grechko) unloaded the Splav-01 electric furnace from the Progress 2 cargo spaceship in January 1978. The same furnace was used by the Dniepers for their smelting experiments.

The first of the Kristall units was replaced shortly after it had been used for a series of tests by the photons (Kovalenok and Ivanchenkov). A second Kristall unit was returned to Earth by the Protons (Lyakhov and Ryumin) after it had malfunctioned. The Kristall 3 furnace which the Dniepers used was, therefore, the longest serving unit of the series to date. Studies of the Kristall 2 and temperature profile characterisation experiments on Kristall 3 have enabled the Soviet materials smelting specialists to obtain optimum performance from the unit, enabling the Dniepers to obtain higher quality melts.

Semiconductor crystals obtained in the Splav and Kristall units have generally exhibited a more homogeneous texture than Earth-produced smelts. For example, the Polish Sirena capsule (mercury-cadmium-telluride) showed 50% homogenity compared to Earth-produced samples which were typically 10 to 15% homogenous.

The flight plan for the Dniepers included substantially more materials processing experiments than earlier crews and included certain new characteristics intended to experiment with the types and quality of melts the Salyut configuration could provide. For example, cooling times of certain types of melts in both the Splav and Kristall furnaces was maximised at 5 days (typical cooling times were on the order of 10-12 hours). During cooling, all Salyut thrusters are deactivated to prevent disruption to the mixture in the ampules.

The 5 day smelting experiments were made with mixtures of cadmium-mercury-telluride. The Soviets have high hopes of this combination which they call by the Cyrillic acronym KRT. The mixtures obtained in earlier experiments have found their way into, amongst other things, infrared body scanning devices, one of which was flown aboard Salyut to record the crew's body temperature. The KRT material is obtained by fusing cadmium telluride with high density mercury telluride. In terrestrial conditions these materials are subject to stratification and, as such, production is very expensive for even small amounts. About 50 mg of KRT is required for one IR detector.

The first experiments with KRT showed that only 5 to 10% of the crystals met the requirements. That figure has now improved many-fold. The KRT structures obtained to date show an almost ideal crystal structure. Production is at a temperature of 1,000°C which produces about 100 atmospheres pressure. Droplets of mercury applied to the outside of the capsule furnace, and their resultant evaporation, balanced the internal pressure.

In Salyut operations, a durable steel capsule is delivered with 3 compartments, each containing very pure quartz. Each ampule contains KRT. The capsule is put into the Splav furnace and heated to 1,000°C. Fusion gradually takes place and the temperature is gradually reduced to allow crystallisation to begin. The end product is a crystal. To emphasise the quality, the Soviets say that while only small portions of Earth-produced KRT are usable, all of the Salyut-produced KRT is usable. Other compounds produced in the Salyut experiments and used in IR devices are cadmium-mercury-selenium and tin-lead-tellurium.

Other compounds produced during the Dniepers' flight included semiconductors of indium antimonide, indium arsenide, gallium arsenide and gallium antimonide, gallium bismuth, monocrystals of germanium, cadmium sulphide, gadolinium-cobalt (for use in computer electronics) and bismuth-oxyllaride.

The Dniepers also investigated a new way of melting crystals by rotating the Salyut to explore the effects of directed microgravitation on crystallisation of solid solutions of metals. Active melting of the crystals during the rotation experiment was done while the crew controlled the operation; normal melts were conducted automatically while the crew were asleep to avoid and movements. Despite the outlay by the Soviets, some observers doubt that they have the necessary Earth-based basic materials research facilities and experience to properly capitalise upon their substantial lead over the rest of the world in this area of space science.

The Vaporiser Experiment

In January 1975, during their 30 day flight aboard Salyut 4, cosmonauts Gubarev and Grechko (the Zentis) recoated the mirror of the station's Orbital Solar Telescope (OST) using an aluminium globule which was melted by a tungsten wire carrying an electric current. The experience proved valuable for Soviets experts designing and instrument to recoat surfaces

in future space stations. To this end, the Dniepers conducted tests with a device called Evaporator.

The 24 kg instrument, which uses the same airlock and control panel as the Splav furnace, was first tested late in the flight of the Protons who managed to produce 24 samples before their return to the Earth. Initially the Protons experienced problems in setting up the device but once they resolved them the crew left an operational instrument for the Dniepers to conduct a whole range of experiments during the first months of their flight.

The evaporator instrument applies metallic coatings in a vacuum and weightlessness to small samples of materials such as titanium and carbon discs. The instrument uses a low-voltage electron beam gun to inject a non-focussed flux of electrons to melt metals in a crucible. From there the metal is vaporised and sprayed onto the surface of the sample where it condenses to form a coating. Low-voltage is used because it does not generate X-rays, and defocussing does not burn. Open crucible melting avoids vibrations from the station due to crew movements, etc., which could form gas bubbles on the coating. The coating thickness depends upon the intensity of the evaporation of the metal in the crucible and the exposure time, which varies between 1 and 200 seconds, depending on the thickness of the coating or the material used. The Dniepers managed to achieve coating thickness of several microns.

A total of 196 samples were coated by the Dniepers and the range of materials used was complex, including gold, silver, copper, aluminium, cupronickel alloy, aluminium alloys, etc. (the Protons used only silver coatings on titanium to prove the concept). Materials coated included metal, glass and titanium.

Uses envisaged for the future versions of the device included aluminium coverings on mirrors for large telescopes and thermo-regulation materials for stations and portholes. Polymeric coatings could be applied (e.g. flouroplastics or silicon oxides).

Hungarian cosmonaut B. Farkas who visited Salyut 6 in Soyuz 36 while Popov and Ryumin were aboard.

Earth Observations Programme

A total of 27% of the Dniepers' working time was devoted to studying the Earth and photography of its natural resources. Almost 3,500 multi-spectral photographs were taken with the MKF-6M camera and almost 1,000 with the KATE-140 topographic camera. The photographs from the latter will be used to provide the cartographic basis for contour maps. In addition, over 1,000 photos were snapped of opportunity targets by the crew with the GDR-made Praktika and Pentakon cameras.

Over 40,000 spectrograms have been returned to the Earth from the Sperktr 15, RSS-2M abd VPA-1 instruments. These observations in the terminator, atmosphere and contrast series of experiments studied the spectral and optical properties of the atmosphere. The BPR - made Duga instrument was used to obtain spectrometry of atmospheric and ionospheric optical properties and emissions.

The mission was timed to coincide with the growing season in the USSR. Popov, a farmer's son, was interested in observing the climatic zones of the USSR for the benefit of agriculture; the flight began at the time of sowing and ended just after the harvest. During the 185 days of their flight they followed the progress of the growing season and, using the Earth-Orbit TV link, spoke to experts in forestry, glaciology, agriculture and other disciplines. The crew became adept at predicting harvest yields; on one occasion they estimated the yield of grain crops around Voronezh as 30 quintals/hectare - the actual turned out to be 34. Dust storms were observed to predict their occurence and a specific list of observations were made in the forestry observation programme.

The programme, mapped out pre-flight, included studies of tree varieties in seven areas. These were: pines in Altay Kray, Voronezh Oblast; almond groves in Kirghizia, Saksaul and Balkhash; cedars and birches in the Transbaikal and larches in Amur Oblast and Maritime Kray. During the dry season the crew reported the location of many forest fires and received messages of thanks from the firefighters for their timely warnings.

Regular MKF-6M photography was conducted over test areas of the USSR, located near Voronezh, Lake Baikal, Ukraine and Kirghizia. The VTR was effectively used to check the areas photographed and simultaneous air and ground-based data collection activities were conducted. At best Salyut observations are available to agricultural specialists after 16 days.

In oceanographic studies the cosmonauts had much to offer. In May/June, Salyut data was used to aid the Soviet research ship *Akademik Kurchatov* which was studying sudden atmospheric changes which create atmospheric and 'submarine' storms in the area of the mythical 'Bermuda Triangle'.

Evidence for intense marine life in the open ocean, as well as coastal regions - where most fishing is concentrated - was obtained. Such observations, which also show where shoals of fish are located, may soon be radioed directly to the fishing fleets, instead of the crew routing the information *via* FCC. The Dniepers recieved many messages of thanks for information provided from trawler captains. Large unbroken areas of plankton, spotted by surface water colouration, were seen in the Black Sea and fishing fleets were able to move in to catch the shoals of fish feeding on the plankton.

Astrophysical Observations

The Dniepers conducted over 100 hours' worth of operation with the Elena-F gamma-ray detector. The 22.5 kg instrument, delivered by Progress 5 and calibrated by the Protons, has dimensions of 280 x 348 x 477 mm and operates in the 30 to 500 MeV energy range.

During the flight, the cosmonauts had to effect an

emergency repair, which surprised the controllers, when the Elena-F malfunctioned. Without consultation the cosmonauts were able to dissasemble the detector, fashion a pin to replace the malfunctioning part and reassemble it. In another incident connected with the Elena-F experiment a balloon carrying another Elena detector, which was conducting data gathering with the cosmonauts, was lost when its transmitter failed.

The Soyuz 35 crew devoted about 27 per cent of their working time to Earth studies.

The Elena-F experiment measured the angular dependence of the structure of particles. In the region of the Brazilian magnetic anomoly (called the South Atlantic anomoly by US scientists) increased streams of high energy electrons were recorded.

BST-1M observation continued sporadically throughout the flight, including repair work already discussed. The cycle of observations of thermal radiation in the atmosphere showed, among other things, small scale variations in brightness of atmospheric radiation in the submillimeter range in areas where cyclonic activity originates.

In an experiment important for future interplanetary navigators the Dniepers were the first Soviet crew to measure their position in space using the stars as reference points with the S-2 sextant. When the Earth was used as a reference point the error in position amounted to 2-3°.

Biology/Botany Experiments

Results of earlier plant growing experiments on Salyut 6 showed that flowering plants tended to wilt in space and even plants provided with a light to grow towards showed little improvement over their unlit counterparts. The 'soil' was a fibrous material moistened with nutrients applied with a spray. Root vegetables, also used to supplement their diet, proved to be the best developers.

In an improved Oasis device green onions were cultivated; the first 'harvest' reached a height of 10 cm by 5 May when they were picked and resown by 11 May. After showing few signs of ripening, the 11 wheat seeds the Dniepers had planted were stored in a preservative solution for return to Earth; only 4 seeds had germinated. Via Radio Moscow the crew asked listeners to provide suggestions to aid plant growth. One of the more imaginative ideas was to place the plants in a magnetic field.

Popov and Ryumin were the first cosmonauts on a long flight to put on weight.

Apple seeds, kept aboard Salyut during the Protons' flight, sprouted normally after being planted back on Earth. Other interesting discoveries included:

- weightlessness has no effect upon cellular processes, including transfer of genetic information,
- seeds planted in the biogravistat device constantly exhibited better growth and better overall cell structures and developments than their weightless counterparts,
- orchids,cultivated in the Malakhit minature greenhouse, bloomed. Young specimens and plants in bloom were planted and by 22 May roots of one were protruding from the apparatus. Orchids, suited for dry atmospheres may predominate future orbital green houses,
- amid much excitment, on 2 September, the arabdopsis plant flowered in the Svetoblok apparatus. This was 3-4 days later than their Earth-based controls and was the first success af flowering from a bud in weightlessness.

Electrical stimulation of plants, involving electrical potentials close to Earth's were applied to several samples. The best growth patterns were exhibited when plants were put next to a window. However, an orbital 'day' of 60 out of 90 minutes hampered growth patterns. The amount of light falling on the plants was measured with a photometer to allow biologists to construct a similar situation on the FCC Salyut mock-up.

Spacecraft Habitability

The Dniepers continued the practice of earlier crews in criticising the design of units on Salyut 6 for rectification on subsequent space stations. Following the schedule laid down for the replacement of individual items and units (some of which, like the TV cables, fan blades and motors, experienced considerable wear), the Salyut 6 crews had collectively replaced about 25% of the station's equipment since it was first occupied. The Dniepers alone replaced 50 seperate items, although none were critical for the continuation of the flight. This work, together with the unloading of the four Progress re-supply spacecraft, occupied about 25% of their working time in orbit.

Interior Repairs

The Protons (Layakhov and Ryumin) returned a filter to Earth which displayed signs of corosion, after ground analysis of the mock-up had failed to pinpoint any cause for the corosion. After a quick redesign the Dniepers installed the new atmosphere recycling filters, to schedule, following delivery by Progress 9. After evaluation of their operation the crewmen declared that the smaller units reduced the need for special CO^2 filters. Hydraulic units in the Salyut's thermo-regulation system had reached the end of their service life by the end of the flight and were innaccesible for replacement.

Ryumin is the tallest of the cosmonauts and had to sleep in a different position to the other crew members because he could not fit into the normal sleep station.

In the replacement schedule the cosmonauts encountered a problem which FCC specialists and designers of the station had not anticipated. Because the station was originally designed for an 18 month to 2 year lifetime, and not the near-4 years the Soviets have managed to get out of it, certain panels were screwed so tightly to the walls that they proved impossible to shift until a specially-designed motor-driven screwdriver was flown to the station. During the repair of one control unit the cosmonauts surprised FCC specialists by the speed they effected the repair; later the specialists admitted they had forgotten the crew could work at the panel from any angle in weightlessness - all of their simulations had been done at 1g on the ground mock-up.

In another incident the cosmonauts lost a small cog and spent some days waiting for it to appear on one of the ventilator grills, having been carried there by the gentle air flow of the atmosphere generators. Ryumin thought that future space stations would benefit with the addition of a small lathe for turning certain items.

Crew Comforts

The crew showered monthly and improvements continued to be made in the shower routine and operation. On the first long flight the Taimirs noted that water tended to cling to the walls of the shower cubicle and they had to use towels to mop it up. On the second long flight the Photons assessed the operation of a ring which gathered water clinging to the cubicles as it was slid down; a swimming mask was provided to stop soap getting into

the eyes. The Dniepers were the first to try out a specially designed towelling fabric for drying after the shower; the crew thought it had promise because it fully absorbed the beads of water on them and the shower cubicle walls.

Popov and Ryumin were thanked for helping Soviet trawlers to spot large shoals of fish.

Other toiletry items specially designed for spaceflight included battery driven toothbrushes, toothpaste and an electric shaver with a system for collecting the hairs. US astronauts found wet shaving best in weightlessness.

Medical Kit

The Salyut 6 medical kit contains all of the standard supplies of a first aid box with everything specially designed for the space environment. Items such as pills had to be produced which could withstand vibrations during launch; ordinary pills are joined together in "books" on transparent sheets. The instruments, such as disposable syringes, are attached by velcro

Orchids, liking dry atmosphere may be common in future orbital bases.

to the side of the box.

The kit has rarely been used although Yuri Romaneko did need a course of treatment for toothache on his 96 day flight. The Protons never had to open the box. The Soviets say that, if necessary, an appendectomy could be carried out during the flight using instruments from the kit. Future versions of Salyut will have room for medical examinations by specially trained doctors flown to the station aboard Soyuz T spaceships.

Exterior Condition

After some 3 years in space Salyut 6 was showing, as might be expected, some degradation of its exterior. Ryumin expressed concern particularly over the state of the 20 portholes, which

Popov and Ryumin aged 4.5 milliseconds less than people back on the ground because the effects of relativity over their 185 day flight.

were by now covered in a thin film of 'dust'. This concern was evidenced by regular photography of the portholes with the manual cameras and the Spektr-15 instrument by the Dniepers and their visitors. A smear was still visible where, on his 15 August 1979 EVA, Ryumin had rubbed one window with his glove.

Looking at the outside of the station, Ryumin noted that the vacuum insulation material, sown together with strong thread, was torn in a few areas, probably by micrometeroid impacts. He noted that the solar panel coverings were splintered in some areas with some of the plastic having broken off, exposing the silicon solar cells to damage from the reflected heat from the sation's radiator.

To be continued

THE COSMONAUTS - Part 21

By Gordon R. Hooper

Continued from the April issue

Lt. Colonel Arnaldo Tamayo Méndez

Arnaldo Méndez was born on 29 January in the city of Guantanamo, Cuba. He was orphaned at the age of one; and adopted by foster parents Rafael Tamaya and Esperanza M endez. He began work at the age of 13 as a shoe-shine boy and vegetable seller. His first regularly paid job was as an apprentice carpenter. Following the Cuban Revolution, he joined the Association of Young Rebels, and then the Revolutionary Work Youth Brigades. This enabled him to continue his studying at a technical college.

In December 1960, he enrolled in a course for aviation technicians, and then decided to become a pilot. In April 1961 he left for a one year crash-course at an Air Force Academy in the Soviet Union. He returned to Cuba in May 1962 and was assigned to the Playa Giron Brigade of the Guard. He was later transferred to a pursuit group in Cuba's central region, where he remained until he was selected for cosmonaut training. In 1963, he was promoted to Lt. and placed in charge of an Air Unit's combat training, and in 1967 he was made squadron head. In 1967/68, he was sent to Vietnam to study the conflict with the US.

In 1968, Méndez was promoted to First Lt. and made a military pilot 1st Class. A year later, he was admitted to the General Maximo Gomez Basic College of the Revolutionary Armed Forces where he took advanced Command and Staff Courses. He joined the Communist Party of Cuba in 1968. From 1971-75, he served as staff chief of a fighter brigade, at the same time continuing his duties as a pilot and participating in scheduled flights. In 1972, he was promoted to sub-captain, then in 1973 to Sgt. Major, and in 1975 to Major. Also in 1975, he was named as alternate chief (2nd in command) of a large air unit. In 1976, he was promoted to Lt. Colonel. He has logged over 1400 hours in the air.

In 1977, Méndez was among those selected for the aptitude tests to become candidate Cuban cosmonauts. A large number of AF pilots were chosen for further tests and medical examinations. Nine finalists were chosen, of which four were sent to the Soviet Union in January 1978. The last 10 days of January and all of February 1978 were spent in numerous tests and examinations. The four returned to Cuba, and Méndez and Falcon learnt of their selection on 1 March 1978.

The two men flew to Star Town and began their training on 22 March 1978. In September 1979, Méndez teamed up with Yuri Romanenko in preparation for the joint flight. The two men were launched onboard Soyuz 38 on 18 September 1980. They docked with the orbiting Salyut 6 space station to join the crew of Popov and Ryumin. They returned to Earth after a mission lasting 7 days 20 hours and 43 minutes.

Arnaldo Méndez was the 7th Intercosmos cosmonaut.

Jose Armando Lopez Falcon

Jose Falcon was born in February 1950 and became a pilot at the age of 17.

Falcon teamed up with Yevgeny Khrunov in September 1979, and served as back-up to Méndez, who was launched into space onboard Soyuz 38 during 18 September 1980. Falcon served as Capcom in mission control.

COMSAT NEWS

ANGLO - FRENCH COMSATS

British Aerospace Dynamics Group and the French aerospace company Matra have announced the formation of a joint venture known as Satcom International which will provide communication satellites. These satellites will be based on the OTS spacecraft which completed its third year of successful operation on 11 May (the first OTS was lost in a launch failure on 13 September 1977 and its successors, the European Communications Satellite (ECS) and Telecom 1.

The first proposal of Satcom International will be to the Australian overseas telecommunications commission for a national communications satellite system for that country.

The OTS satellite has already produced three derivative satellite programmes. For European regional communications, British Aerospace Dynamics Group are providing five ECS satellites to carry telephony, TV, data, facsimile and business communications services. In addition, they are also providing two maritime versions which will form an integral part of a global maritime communications network.

For French domestic communications, Matra have developed a further version, Telecom 1, three of which will be built. These satellites will provide data transfer, intra-company telephone, TV transmission and governmental telecommunications services.

MILITARY COMSATS

Despite a rollercoaster-like growth curve, the US military satellite communications market is expected to increase at an average annual rate of 2-3% (in real terms) over the FY 1980-FY 1986 period.

Expressed in current year dollars, the market stood at $495.1 M in FY 1980. It is forecast to rise sharply to $659.6 M in FY 1981, decline to $644.4 M in FY 1982 and $537.7 M in FY 1983, jump to $753.5 M in FY 1984 and $899.8 M in FY 1985, and then edge down to $891.9 M the following year. Applying an estimated 7-8% inflation rate, average annual growth amounts to 10%, the marketing research company Frost & Sullivan points out in its study, "U.S. Military Satellite Communications Market".

The Air Force - responsible for development and acquisition of all spacecraft, launch vehicles and related services - accounted for over half the total market at the beginning of the decade and is expected to maintain its dominance through FY 1986. Funding for Air Force programmes amounted to $270.5 M in FY 1980 and is forecast to reach $500 M in FY 1986, sliding from a peak of $518.5 M in FY 1985.

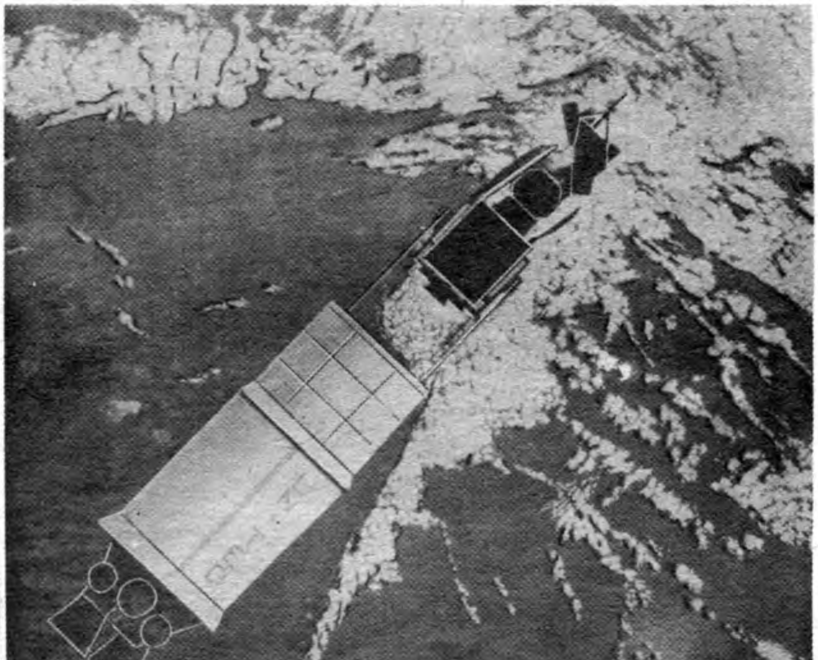
Funding for Army programmes - development and acquisition of ground terminals - is predicted to advance from $158.4 M in FY 1980 to a peak of $209.8 M in FY 1982, drop to $149 M in FY 1983 and rise slowly to $167.8 M in FY 1986. As a consequence, share of the total market will plummet from 32% to 19% over the period, the report notes.

Navy funding is expected to mount from $54.4 M in FY 1980 to $177 M in FY 1986, causing the market share to jump from 11% to 20% during the period.

Appropriations for Defense Agency programmes are forecast to build steadily from $11.8 M in FY 1980 to $47.1 M in FY 1986, with the share escalating from 2% to 5%.

Military satellite communications systems have evolved from early development and demonstration into three major systems shaped to serve specific military needs, the report points out: "The Defense Satellite Communications System (DSCS), Fleet Satellite Communications System (FLTSATCOM) and Air Force Satellite Communications System (AFSATCOM) are the major operating systems today, and they reflect the architecture of military satellite communications systems at least through the mid-1980's. Development (during this period) will focus on the extension of established capabilities under wartime conditions. Survivability, radiation hardening, protection from jamming are typical issues of today."

Two new systems are candidates for full-scale development during the first half of the decade, the study continues. STRATSAT is conceived as a system of satellites orbiting at 110,000 miles altitude to achieve a high degree of protection from hostile attack. Its function would be to carry out the AFSATCOM mission and initial funding is expected to be approved in FY 1982. However, if Congress again turns down a Department of Defense request, it is likely that appropriations



Nearly there. The end of the Atlas Centaur launch sequence for the Intelsat V communications satellites. The two Centaur engines have shut down and the satellite - with its antennae and solar panels still in the stowed position - separates.

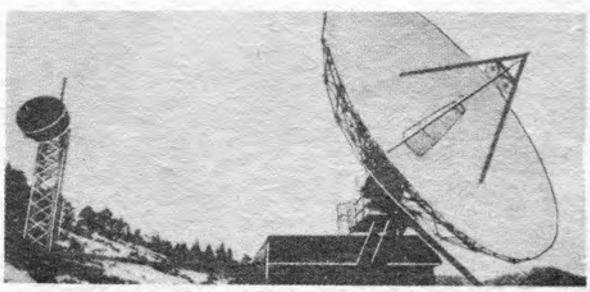
Courtesy Intelsat

will instead be approved for deployment of additional AFSATCOM transponders to achieve improved survivability.

The other new offering, TACSATCOM II, is conceived as a space system designed to preserve the large investment in UHF terminals and, at the same time, extend tactical usage by incorporating EHF capability.

Beyond these and other major projects, development efforts in laser communications are expected to intensify, with particular attention focused on such potential applications as satellite-to-satellite data relay and submarine communications.

Less visible trends expected to continue include the transition on all-digital transmission, increased interconnectivity between systems, increased survivability and protection from jamming. Access to satellite communications will be extended to many more military units, as shown by the procurement of large numbers of satellite terminals.



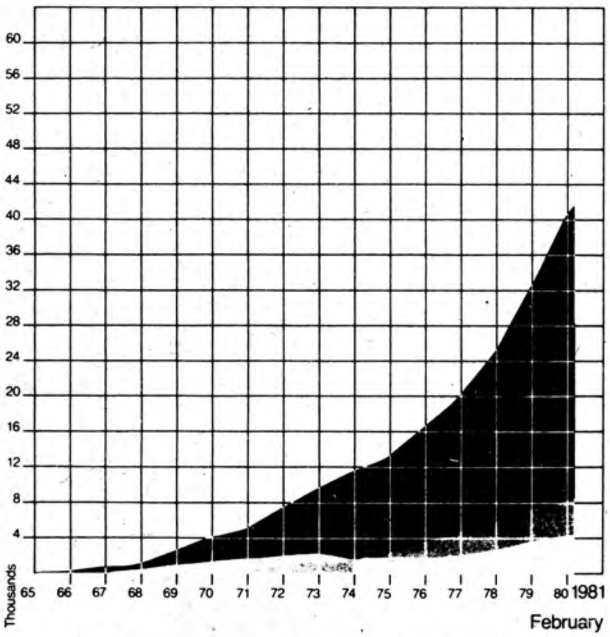
There are up to 700 sea vessels equipped with maritime satellite facilities for communicating with land-based users and each other. The above Earth station at Eik in Norway will be operational by 1982, the first of a series of nine stations which will come into service next year.

EARTH STATION CONTRACT

Marconi Communication Systems Limited has been awarded a contract worth nearly £5M to convert the British Telecom satellite Earth terminal, Goonhilly 4, for use as a Standard C terminal with Intelsat V, the new generation of operational communications satellites.

Goonhilly 4 was originally built in 1978 as an experimental station for use by British Telecom to prove the technology involved in operating in the 14/11 GHz frequency band, working to OTS. With Intelsat V due to become operational on the Atlantic path, British Telecom plans to open the new service during late 1982, connecting Great Britain with other Standard A and C Earth stations in the United States, Central and South America, Africa and the Middle East.

The international demand for satellite communications, ranging from personal and business telephone calls to data transmissions, telex and even television, is such that the present 6/4 GHz frequency band is rapidly approaching saturation point. The growth in demand, particularly among Third World countries (which require cheaper and less sophisticated communications at this stage), is best met by the 6/4 GHz frequency band. A typical example is the Standard B Earth station which is shortly to be built in Nepal, the first satellite link which that country will have with the outside world.



Growth curves (in half-circuits) for the use of Intelsat comsats, which provide two-thirds of the world's overseas comsat capacity. Key: black - global; dark grey - Atlantic; mid-grey - Indian Ocean; light grey - Pacific Ocean.

QUICK ON THE DRAW?

Photographs and Artwork for Publication

We know that photographs and other artwork which appear in *Spaceflight* are eagerly studied by readers who, generally speaking, tend to look for more rather than less in each issue. Unfortunately, the problems of finding, locating and securing suitable items is a formidible task which cannot always be acomplished in the short time-span available.

We have already approached members with artistic bent asking if they would be willing to provide cutaways, line drawings and other material which we could "stock pile" for use as each opportunity arises and now extend this appeal to all other readers who might be able to help.

If any members have, by chance, collections of photographs, diagrams or other artwork suitable for reproduction - including shots, or even drawings of particular interest, no matter if they go back to the year dot - which they would like to donate or provide to Society use, we would be most interested to hear from them.

We are looking for pictures of particular interest, rarity or uniqueness on any astronomical or space-related subject.

As members will know, the Society's publications cover a wide spectrum of interest, ranging from education, through history, up to advanced concepts and even up to the problems of interstellar journeys.

Should members possess pictures which might be suitable though, for sentimental or other reasons, they would prefer not to part with the originals, perhaps they would forward details instead, or even provide a print if one is available.

Members willing to *donate* material are invited to do so without delay. Members unwilling to part permanently with originals but who would allow the Society their use are invited to forward prints or reproductions, if available, or written descriptions if not.

SATELLITE DIGEST - 148

A monthly listing of all known artificial satellites and spacecraft. A detailed explanation of the information presented can be found in the January 1979 issue, p. 32.

Robert D. Christy

Continued from August-September issue

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclin-ation (deg)	Nodal period (min)	Launch site launch vehicle and payload/launch
	1981 Mar 16.88							ESMR
1981-25A	indefinite			geostationary orbit				Titan 3C
12339								DoD/USAF (1)
Cosmos 1259	1981 Mar 17.36	Cylinder+sphere	6 long?	206	382	70.35	90.43	Tyuratam
1981-26A	14 days (R)	+cylinder-cone?	2.4 dia?	348	415	70.37	92.22	A-2
12341	1981 Mar 31	6000?						USSR/USSR (2)
Raduga 8	1981 Mar 18.19	Cylinder+2 panels	5 long?	36544	36544	0.75	1475.04	Tyuratam
1981-27A	indefinite	+antenna array	2 dia?					D-1-E
12351		2000?						USSR/USSR (3)
Cosmos 1260	1981 Mar 20.99	Cylinder?	6 long?					Tyuratam
1981-28A			2 dia?	428	447	65.03	93.34	F-1
12364								USSR/USSR (4)
Soyuz 39	1981 Mar 22.624	Sphere+cone-	7.5 long	198	249	51.78	88.91	Tyuratam
1981-29A	7.863 days (R)	cylinder	2.2 dia	245	315	51.6	90.1	A-2
12366	1981 Mar 30.487	6500?		336	350	51.63	91.33	USSR/USSR (5)
Molniya-3 (15)	1981 Mar 24.15	Cylinder-cone+6	4.2 long?	608	40642	62.73	736.00	Plesetsk
1981-30A	12 years?	panels?	1.6 dia?	624	39732	62.73	717.79	A-2-e
12368		2000?						USSR/USSR (6)
Cosmos 1261	1981 Mar 31.40	Cylinder-cone+6	4.2 long?	588	39405	62.95	710.46	Plesetsk
1981-31A	12 years	panels?	1.6 dia?	593	39756	62.95	717.76	A-2-e
12376		2000?						USSR/USSR (7)
Cosmos 1262	1981 Apr 7.45	Cylinder+sphere	6 long?	196	392	72.87	90.42	Plesetsk
1981-32A	14 days (R)	+cylinder-cone?	2.4 dia?	216	324	72.87	89.94	A-2
12385	1981 Apr 21	6000?						USSR/USSR (8)
Cosmos 1263	1981 Apr 9.51	Cylinder?	2 long?					Plesetsk
1981-33A	30 years	700?	2 dia?	396	1968	82.98	109.06	C-1
12388								USSR/USSR
STS-1	1981 Apr 12.500	Aeroplane	37 long	98	235	40.29	87.69	ESMR
1981-34A	2.265 days (R)	68800	24 span	238	250	40.35	89.26	STS Columbia
12399	1981 Apr 14.765							NASA/NASA (9)
Cosmos 1264	1981 Apr 15.44	Cylinder+sphere	6 long?	208	385	70.36	90.48	Tyuratam
1981-35A	14 days (R)	+cylinder-cone?	2.4 dia?	362	416	70.38	92.35	A-2
12400	1981 Apr 29	6000?						USSR/USSR (10)
Cosmos 1265	1981 Apr 16.48	Cylinder+sphere	6 long?	198	287	72.85	89.39	Plesetsk
1981-36A	12 days (R)	+cylinder-cone?	2.4 dia	226	289	72.84	89.69	A-2
12402	1981 Apr 28	6000?		224	356	72.84	90.37	USSR/USSR (11)
Cosmos 1266	1981 Apr 21.16	Cylinder?	6 long?	248	267	64.97	89.66	Tyuratam
1981-37A	500 years		2 dia?	892	968	64.76	103.64	F-1
12409								USSR/USSR (12)
SDS 7	1981 Apr 24							WSMR
1981-38A								Titan 3B/Agena D
12418								DoD/USAF (13)
Cosmos 1267	1981 Apr 25.08	Cylinder+panels	15 long?					Tyuratam
1981-39A		15000?	4 dia?	192	260	51.59	88.96	D-1
12419								USSR/USSR (14)
Cosmos 1268	1981 Apr 28.37	Cylinder+sphere	6 long?	208	368	70.41	90.31	Tyuratam
1981-40A	14 days (R)	+cylinder-cone?	2.4 dia?	241	366	70.38	90.62	A-2
12423	1981 May 12	6000?		223	248	70.37	89.24	USSR/USSR (15)
				224	282	70.38	89.58	

Satellite Digest-148/contd.

Cosmos 1269 1981-41A 12442	1981 May 7.56 120 years	Cylinder+paddles? 750?	2 long? 1 dia?	794	808	74.06	100.94	Plesetsk C-1 USSR/USSR
Soyuz 40 1981-42A 12454	1981 May 14.719 7.86 days (R) 1981 May 22.58	Sphere+cone- cylinder 6800	7.5 long 2.2 dia	192 258 262 331	270 307 350 345	51.62 51.62 51.63 51.63	89.05 90.10 90.58 91.22	Tyuratam A-2 USSR/USSR (16)
Meteor 2 (7) 1981-43A 12456	1981 May 14.91 500 years	Cylinder+2 panels 2500?	5 long? 1.5 dia?	853	892	81.27	102.46	Plesetsk A-1 USSR/USSR (17)
Nova 1 1981-44A 12458	1981 May 15.26 5000 years			353 1173	935 1203	90.16 89.97	97.67 109.22	WSMR Scout DoD/USAF (18)
Cosmos 1270 1981-45A 12461	1981 May 18.49	Cylinder+sphere +cylinder-cone? 6000?	6 long? 2.4 dia?	173	348	64.86	89.72	Tyuratam A-2 USSR/USSR (19)
Cosmos 1271 1981-46A 12464	1981 May 19.16 60 years	Cylinder 1 2 panels? 2500?	5 long? 1.5 dia?	626	649	81.22	97.52	Plesetsk A-1 USSR/USSR (20)
Cosmos 1272 1981-47A 12466	1981 May 21.38 14 days (R) 1981 Jun 4	Cylinder+sphere +cylinder-cone? 6000?	6 long? 2.4 dia?	208 360	379 415	70.37 70.39	90.43 92.36	Plesetsk A-2 USSR/USSR (21)
Cosmos 1273 1981-48A 12469	1981 May 22.30 13 days (R) 1981 Jun 4	Cylinder+sphere +cylinder-cone? 6000?	6 long? 2.4 dia?	211	249	82.32	89.15	Plesetsk A-2 USSR/USSR

SUPPLEMENTARY NOTES:

(1) DoD payload stationed at 71° east longitude.
(2) Orbital data are at 1981 Mar 17.4 and Mar 21.3.
(3) Communications satellite at the Statsionar 2 location (35° east longitude).
(4) Reconnaissance satellite, possibly working in conjunction with Cosmos 1220 (1980-89A).
(5) Manned ferry carrying the International crew of Vladimir Dzanibekhov and Jugderdemidiyn Gurragchaa of Mongolia to Salyut 6. Soyuz 39 docked with the rear unit of Salyut 6 at 1981 Mar 23.686 (1628 UT). Orbital data are at 1981 Mar 22.7, Mar 23.0 (estimated data) and Mar 24.3.
(6) USSR communications satellite. Orbital data are at 1981 Mar 24.2 and Apr 8.3.
(7) Possibly a missile early warning satellite. Orbital data are at 1981 Mar 31.5 and Apr 4.4.
(8) Orbital data are at 1981 Apr 7.5 and Apr 10.2.
(9) First test flight of the Space Transportation System, flown by astronauts John Young and Robert Crippen. The craft landed on a dry lake bed at Edwards Air Force Base, California. Orbital data are at 1981 Apr 12.5 and Apr 12.51.
(10) Orbital data are at 1981 Apr 15.5 and Apr 16.3.
(11) Orbital data are at 1981 Apr 16.5, Apr 17.3 and Apr 24:3.
(12) Ocean survey satellite which appears to have terminated its mission early. Orbital data are at 1981 Apr 21.3 and Apr 29.9.
(13) DoD communications satellite.
(14) Test flight of the 'Star' space station module, related to Cosmos 929 (1977-66A). The initial orbit plane was ten degrees to the east of that of Salyut 6. By virtue of the two vehicles' differing heights, the difference reduced slowly to allow the new craft to dock with the rear unit of Salyut 6 on 1981 Jun 19.
(15) Orbital data are at 1981 Apr 28.4, May 2.2, May 2.6 and May 8.1.
(16) Manned ferry carrying the last communist country's international crew to Salyut 6. Flight Engineer Dmitru Prunariu of Roumania accompanied mission commander Leonid Popov — making his second visit to Salyut 6. Soyuz 40 docked with the rear unit of Salyut 6 about 25½ hours after launch. Orbital data are at 1981 May 14.9, May 15.0, May 15.7 and May 17.2 (after docking).
(17) Meteorological satellite.
(18) US Navy's improved TRANSIT navigation satellite. Orbital data are at 1981 May 16.2 and May 29.2.
(19) Long life, manoeuvrable reconnaissance satellite.
(20) Probably an electronic ferret.
(21) Orbital data are at 1981 May 21.4 and May 22.5.

DECAYS:

Designation	Name	Date	Lifetime (d)
1969-68A	OSO 6	1981 Mar 7	4228
1972-23A	Cosmos 482	1981 May 5	3322
1975-69A	Cosmos 752	1981 Feb 28	2046
1977-6A	Cosmos 891	1981 Feb 4	1463
1977-60A	Cosmos 924	1981 Feb 10	1317
1978-49A	Cosmos 1008	1981 Jan 8	967
1978-99A	Intercosmos 18	1981 Mar 17	875
1978-115A	Cosmos 1062	1981 Apr 20	857
1980-43A	NOAA-B	1981 May 3	339
1980-52A	Big Bird	1981 Mar 6	261
1981-20A	Cosmos 1248	1981 Apr 4	30 (R)

AMENDMENT:

Soyuz-T4, 1981-23A was recovered 1981 May 26.526, lifetime 74.734 days.

OUR SPACE LIBRARY

We are seeking many technical books and similar items on astronomy, space research and space technology, and would welcome hearing from members with material they would like to donate to us to help fill the gaps.

Please write to the Executive Secretary first of all, indicating what you would like to present to us.

The Library will be open to members from 5.30 - 7.00 p.m. on each of the following dates:

7 Oct 1981	14 Oct 1981
18 Nov 1981	2 Dec 1981
20 Jan 1982	10 Feb 1982
24 Feb 1982	11 Mar 1982

SOCIETY MEETINGS

SPACE TRANSPORTATION OF THE FUTURE

The Society's Space Technology Committee implements Council Policy by seeking to identify and encourage technical discussion of various options and identify a viable and coherent European policy, complimentary to that of the USA but with its own unique features and contributions. As part of its programme, the SPC holds an Annual Symposium to review trends and directions in Space Transportation.

The proceedings of the last Symposium, reported below, will form the basis of a Report to be sent to appropriate policy-making bodies.

On 15 April the BIS played host at its HQ building to about thirty engineers and interested Members attending the 'Space Transportation Systems for the 1990's' one-day symposium chaired by Peter Conchie.

The meeting was aimed specifically at European systems for the 1990's and beyond. Possible approaches were described in a series of papers, followed by a round-table discussion during which the chairman and three contributors presented their views on what Europe's aims should be for the 1990's. The subject was then opened for debate.

We have seen that the US Space Shuttle is, at least, usable. Europe's new launcher has had its problems but its level of technology is such that we can expect it to become a successful, commercial enterprise. But what comes after the basic Ariane I version? J. Bouillot of CNES, the French space agency, described what could happen for future Ariane versions, some of them already in a firm state. Ariane III was given the go-ahead by ESA in 1979 and should fly by the middle of 1983. Its payload capability must make it attractive to compete with the Shuttle and by adding two strap-on boosters, improving the engines, lengthening stage 3 to carry 25% more propellant and redesigning the payload shroud, it will be able to put 2050 kg into a geosynchronous transfer orbit.

Ariane III will be able to launch *two* medium-class satellites or a single large craft of the L-Sat type. This approach will satisfy demands to about 1985 but in 1986, for example, we should see the new Intelsat VI comsats which will require Ariane IV, a vehicle ESA will decide upon this year.

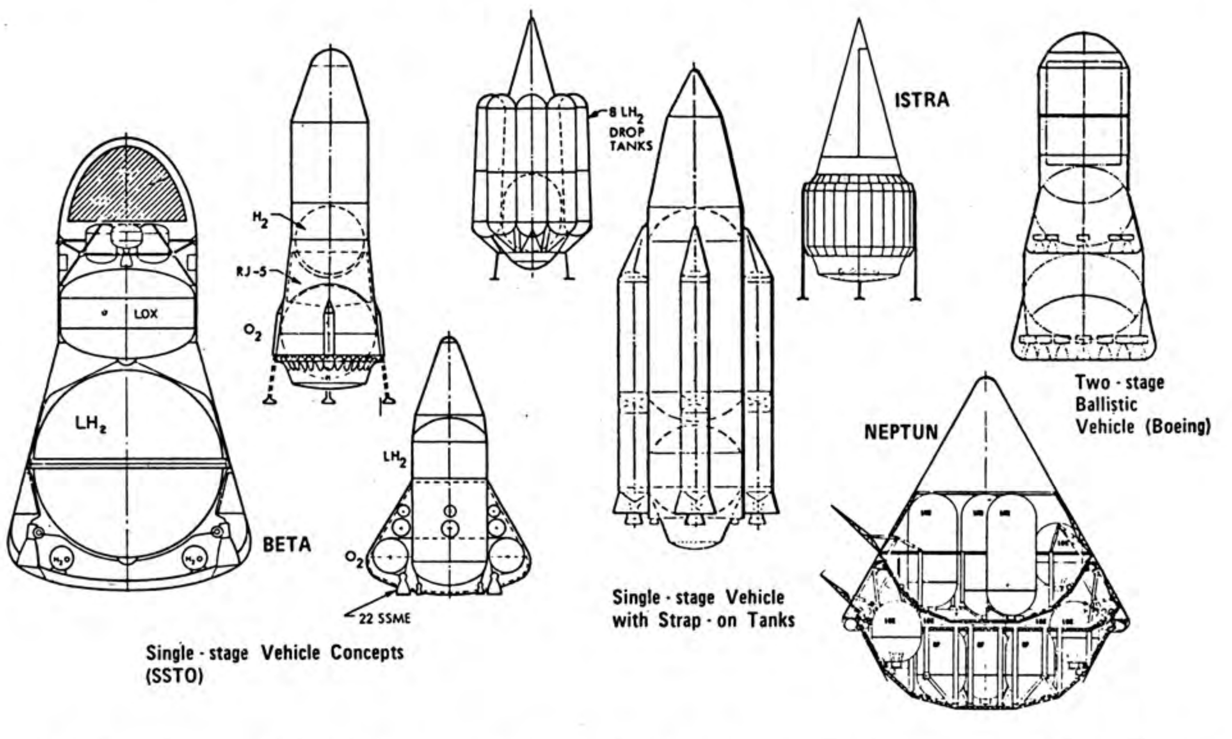
The II, III and IV versions will co-exist for a few years until only the latter is left.

Ariane V may be the European launcher of the 1990's if we begin development in 1984. Present ideas include a reusable first stage, a liquid oxygen/liquid hydrogen second stage and an optional third stage. The two-stage version could put 11 tonnes in low Earth orbit, possibly even a small European shuttle.

Ariane V is only one possibility for the 1990's. D. Koelle of MBB looked at the requirements and possible solutions for that decade. Comsats plus a few scientific Earth resources, planetary, etc. craft will be the main payloads so the launcher should be able to handle 3 to 5 tonnes to geosynchronous orbit or 10 to 15 tonnes to low Earth orbit. Its cost/unit payload mass should be less than Ariane I - to be competitive with the Shuttle - and, ideally, the LEO payloads should be retrievable (payloads such as expensive astronomical satellites).

There are many variables to be considered: reusability, number of stages, propellants, costs (development and operating), whether it should be winged and/or manned, etc. Possible solutions include a clustered Ariane (cheap to develop but expensive to operate) and Ariane with a reusable second stage. One of the best appears to be a reusable, single-stage-to-orbit launcher with a large diameter to accommodate large payloads. Europe needs to decide in the next few years in order to have a vehicle available for the 1990's.

David Ashford of BAe covered a similar topic in discussing a *mature* space transportation system, meaning a system which was at the same stage as today's commercial aircraft. They would, he believed, be single-staged and winged, use horizontal take-off and landing, carry hypersonic air-breathing engines and be reusable. The cargo target cost is about $5/kg to



Advanced ballistic vehicles studied in the past. Reproduced from D. Koelle's paper "The Next Generation of Launch vehicles" in the May 1981 *Space Chronicle, JBIS.*

Reconvening the meeting after a well-earned tea-break!

low Earth orbit (two orders of magnitude lower than the present Shuttle).

A new propulsion system with a specific impulse of about 800 s (the Shuttle main engines are about 460 s) is needed. To reach that stage we would have to go through an evolutionary process but by beginning now with the familiar 'Spacecab' proposals of Mr. Ashford (described in the *Space Chronicle JBIS* in January 1981) we would have such a mature low Earth orbit shuttle in about 2010. Then would come geosynchronous orbit, the Moon, planets and, possibly, the nearer stars.

A large portion of the payloads (i.e. comsats) in the coming decades will require transfer from low Earth orbit to geosynchronous altitude. Yet the Shuttle/Centaur will be able to handle only about 6000 kg. Obviously, this is not much use when we are talking about Solar Power Satellites some 10 km long! For large platforms or SPS sections we will probably need propulsion modules which can be attached to a unit in order to deliver it to geosynchronous altitude. These platforms will be so large that they will not be able to withstand much acceleration and we will have to resort to relatively low thrust, long transit time systems.

One suggestion is to produce Shuttle-launched modules carrying four advanced 5000 lbf engines. These modules can, in turn, be clustered into groups of five. But liquid engines are limited to rather low specific impulses and are perhaps more suited to 'brute force' jobs. David Fearn of the RAE sugested that electric propulsion would be more suited to the task; although they produce low thrust (the inertial Upper Stage has a thurst to weight ratio of 1.15 while a typical value for an electric engine is 0.001!) they can operate for years at a time. The low Earth orbit would thus gradually spiral outwards and become geosynchronous.

The major problem with a trip of hundreds of days for an SPS section is that slow passage through the radiation belts would damage the solar cells. Laser annealing, though, may be able to protect them sufficiently.

Construction crews and priority cargoes would use a quicker, chemical engine system for *their* transport.

The very last paper of the symposium might have seemed exotic at any normal meeting but, compared with the rest, it appeared very down-to-Earth indeed. Bob Parkinson, known to Members as author of 'High Road to the Moon', presented his plans for a manned mission to Mars in 1995 (without the need for nuclear propulsion). Is a manned flight necessary at all? Dr. Parkinson argued that it would be cheaper than sending a series of Viking follow-up probes (geophysical orbiters, surface penetrators, rovers, sample returners, etc.), plus a flyby of Venus was included.

The trip would be based on three vehicles carrying five men, initially taken into space by eight launches of the heavy lift shuttles expected to be available by the mid-1990's. Each 132 tonne vehicle would then be propelled towards Mars by an upper stage to begin the 560 day mission. The three - two orbiters and a lander/orbital transfer vehicle/robot probe store would dock together for the duration of the outward leg with the crew living in Spacelab-derived modules.

The lander - the only section needing design and construction from scratch - would look rather like an Apollo command module and be 7.6 m across the base. The three explorers would return to Mars orbit in a liquid-propelled section launched from the lander's centre.

A visit to Phobos is also possible during the 45 day Mars stay.

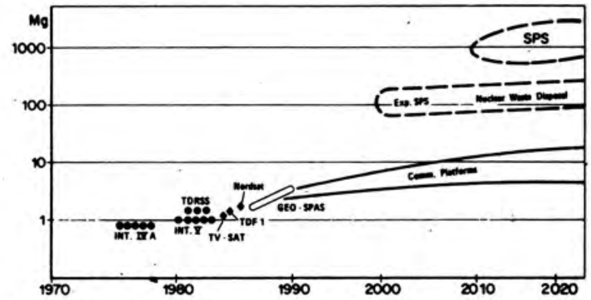
The trip back to Earth would include a flyby of Venus in December 1995 before Earth arrival in 1997. Estimated cost is comparable with Viking.

In the round-table discussion which followed, the unanimous opinion - appropriate in the light of Shuttle Columbia's landing the previous evening - was that space travel was becoming a commercial enterprise. Europe needs to define her targets more clearly; the nature of our organisation means that we have a different approach to that of the U.S. We cannot compete with them in manned flight but, as part of the progress towards permanent space stations, we should press for Spacelab free-flying modules to be built.

It was noted that while Europe was becoming more involved with Solar System exploration - for example, Giotto and ISPM - the U.S. appeared to be drawing back.

They, of course, are not unaware of the rapid growth coming in space-based communications systems. We should also adopt a positive attitude, but our problem is that the development of Ariane into more advanced forms is not rapid enough to keep pace with the increase in comsat sizes.

The story of Europe's past involvement in space launchers has been too little too late - we should not allow it to happen again.



A projection of possible future payload requirements to GEO (the vertical scale is in Megarams, ie tonnes). In the shorter term there are comsats, later ones being direct-broadcast, and then communications platforms. Heavier of all are the Solar Power Satellites at upper right.

Papers presented at the Symposium

J. Pocha, "Comparison between Ariane and Space Transportation systems".

P.J. Waples, "Transportation Requirements for future Communications Missions".

R. Shelton, "Transportation Requirements for Solar Power Systems".

J.C. Bouilllot, "Ariane Today and Tomorrow".

D.E. Koelle, "European Launch Vehicle Alternatives Beyond Ariane 4".

A.W. Preukschat, "construction of Multi-Payload Communication Systems in Geostationary Orbit".

D.Fearn, "A Review of Future Orbit Transfer Technology".

C.M. Hempsell, "A Low Cost Approach to Interplanetary Exploration'.

D. Ashford. "Towards Mature Space Transportation".

R. Parkinson, "A Manned Mars Mission for 1995".

DAEDALUS — THREE YEARS ON

The publication of the British Interplanetary Society's Daedalus report three years ago created a wide surge of interest. Here was the outline of a daring plan to build a starship using forseeable technology to go to one of our neighbouring stars. Newspapers and magazines throughout the world included features on Daedalus, promoting the notion that interstellar travel was not so far off after all.

On 6 May a one day symposium on the theme of *Daedalus In Retrospect* was held in the Society's Golovine Conference Room to look at developments since 1978. Alan Bond, the study's leader, suggested that the general conclusions had not changed since the report's publication and, in fact, work in fusion technology had gone towards showing that Daedalus' propulsion system *is* feasible.

Daedalus uses small pellets - with a deuterium honeycomb and liquid helium-3 filling - injected into a shaped magnetic field, where they are irradiated by electron beams. The outer shell blows off because of the sudden heating and a shock wave travels inwards to initiate the fusion reaction. The heating has to take place at high electron energies and over a very short time (a few one thousand-millionths of a second!), otherwise ignition will not occur. Research into this type of process has been going on - much of it classified - and we are still well short of the target energies and times. But these are still early days and the signs are hopeful.

Ion beams and lasers are also being studied; the trouble with the latter is that they are very inefficient (a few per cent) and have to be uniformly spread over a small, spherical target. Another method is to accelerate the fusion pellets themselves and smash them into targets to generate shock waves.

So the Daedalus ignition system may well differ from the 1978 report but the overall propulsion design stands firm.

Gerry Webb addressed the problem of what experiments and probes should be carried and how the target encounter should be carried out. Various types of probes were included (to investigate the interstellar medium, stellar physics and look at the gas giants and terestial planets of the target system), with their experiment philosophy based on NASA's Voyager craft, *albeit* updated. The magnificent successes of Voyager since the Daedalus report was published illustrate the sound choice of that philosophy, but modifications to the original plan should be considered. Daedalus, travelling at 25,000 miles/second, would have less than a day to scan the entire Barnard system and, for example, would have less than a minute of close-encounter with a Jovian-class planet.

Bill Dillon prepared the original artwork for the *Daedalus* report and presented the five paintings (four were included in the report) to the Society about a year ago. The *Daedalus* retrospective meeting provided Bill with the perfect opportunity to donate yet another painting, magnificently framed and depicting the vehicle before the beginning of its journey to Barnard's Star. L. J. Carter, Executive Secretary, thanked the artist on behalf of the Society and commented that it would be greatly valued.

Alan Bond had already mentioned the amount of artwork inspired by the project in various books and magazines and Mat Irvine, BBC modelmaker and BIS member, brought along models used in the BBC's *Spaceships of the Mind* series of 1977.

Daedalus in Retrospect, part of the presented programme:

A. Bond	**Propulsion System Update**
M. Irvine	**Construction of the Daedalus Model (plus the BBC film 'Spaceships of the Mind')**
G. M. Webb	**A Reappraisal of the Daedalus Payload**
E. J. Coffey	**When the Wardens Fail: Robots, Intelligence and Daedalus**
J. G Andrews	**Daedalus Computer System**
T. J. Grant	**Reliability and Maintainability Improvement with Technological Progress** **The Application of Time-varying Failure Rates to Daedalus** **The Application of Artificial Intelligence to On-Board Repair Facilities**
C. Viles	**Project Foundation Work**

We should therefore consider some sort of deceleration procedure for the probes in order to give them longer look times at their targets . With about 260 tonnes allocated to probes, it may be worthwhile sacrificing some of the experiments.

Another problem we have to face is that of the target system. Daedalus chose Barnard's Star but we do not yet know with certainty that it has planets of its own. The Space Telescope, due for Shuttle launch in 1985, may answer this question and we could end up with a new target. If it differs appreciably from Barnard's Star - in spectral class, for instance - then the experiments would have to be changed.

The entire craft and probes need repair and maintenance throughout the flight, of course, and this led Tim Grant to introducing the 'Warden' concept. The Wardens are independent robots, more advanced than anything we have now, which could repair or replace failing equipment, including each other. Further studies have shown how important the Wardens are for the mission success and at least, say, 5 should be carried. They would not be intelligent in the human sense (Enrico Coffey presented his reasoning for this) but should be capable of making decisions without human intervention.

Their job would be easier if the different types of probes (and even themselves) were built in modular form so that power, communications, etc. units could be used more than once. This reduces the overall complexity, a factor in keeping the number of Wardens down.

Tim Grant's major concern for Daedalus is the repair and maintenance aspect. At the time of the report there was not a great deal of information on spacecraft component failure rates and he based his Daedalus estimates on figures from the aircraft industry. These show that component reliability drops to a few per cent after only 3 years; new data for spacecraft suggest the figure should be something like 90%! Are Wardens necessary at all? Estimates using the new information and assuming triple redundancy with no repairs still gives a lifetime of only about 12 years, whereas the mission lasts for 50. So Wardens are necessary but the revised data suggets that more work needs to be done on what spares and repair facilities are needed.

So the consensus of the meeting was that the 1978 Daedalus is still feasible although, as we should expect anyway, the detailed design would probably turn out to be quite different.

The BIS Moonship of the 1930s has gone down in the history books as being an important development in astronautics. Daedalus deserves the same fate.

SOCIETY NEWS

THE HQ RAILINGS SAGA!

Among the stories behind the purchase and development of the Society's HQ Building which have yet to be told, one concerns the railings which adorn its front facade.

When first acquired, our present HQ consisted of two separate buildings, vandalised and derelict. Number 29 was "the house dating from the first half of the 19th Century," and number 27 was "the old Dalton's Weekly building". "The house" was protected as a Class 2 Listed Building.

Part of this protection extended to its front railings, originally headed by cast-iron fleur-de-lis and mounted on a stone plinth. Unfortunately, these had all been destroyed by acquisition. Only a tiny piece of the top of one railing was found.

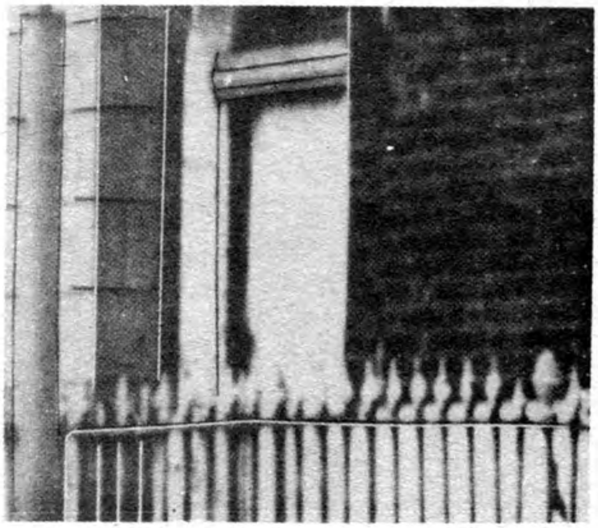
Armed with this, our Executive Secretary contemplated how to have the railings reconstructed. It occurred to him at this point that it would be nice if similar railings could also be built along the front of number 27 also. The two would then blend, the main door would be nicely set off and a pleasing appearance obtained.

Unfortunately, the front of number 27 abutted directly on the public pavement. Not put off by this, Len Carter then opened negotiations with the Greater London Council to try to obtain a 99 year lease of part of the pavement, sufficiently wide to enable railings to be erected.

The GLC response was brief and to the point. They would grant a lease for 6 months only, renewable every 6 months thereafter and the Society would have to pay all legal costs as well as abide by 8 other conditions and pay an initial rental of £40.00 per annum, a charge which would obviously be increased at each 6 monthly renewal.

At this point fate intervened.

Quite by chance, Len visited a local book shop and accidently picked up a book called "Victorian Childhood". It flew open at its one and only illustration. Incredibly, it was a picture of a house which was the mirror image of number 29. Intrigued, Len bought the book and read it that evening. The house shown had stood in north London but the text included a description of it, during which it was casually mentioned that it *was one of a pair* of semi-detached villas.

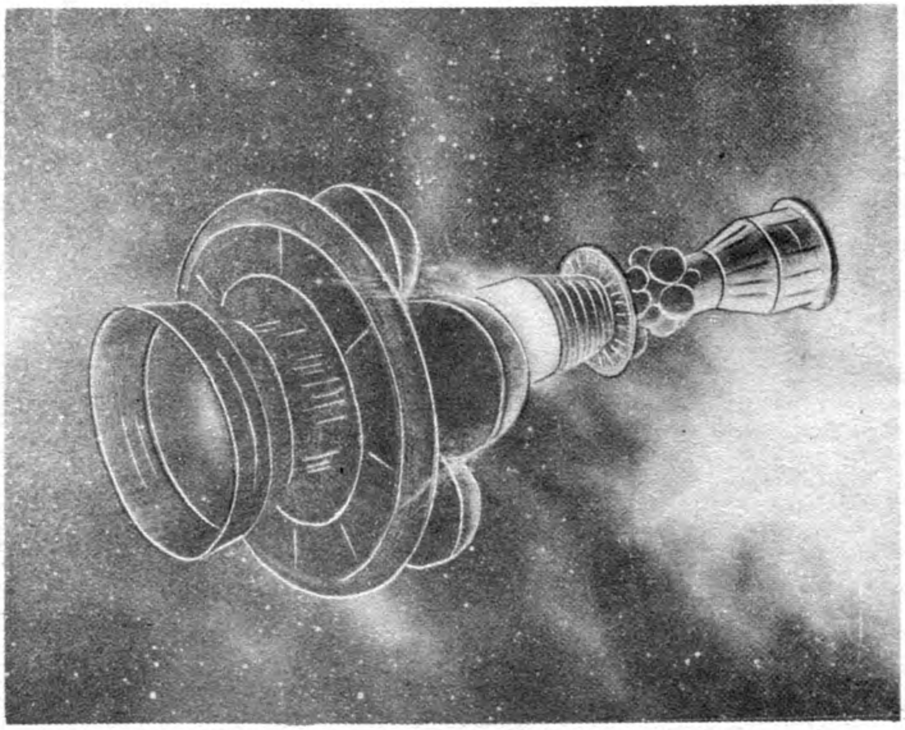


The railings to be preserved, as they were before the building was purchased and before theft by scrap-iron dealers. The acorns were a feature of this structure.

Shades of Sherlock Holmes followed. If this had been one of a pair, reasoned Len, then its counterpart in South Lambeth Road must have also been one of a pair. But here was the rub: only one remained. Obviously, the Dalton's building had blotted out its companion. That being so, where was the space for its railing?

Underneath the GLC pavement, beyond any doubt!

The next letter to the GLC differed markedly from its forebears. Please explain GLC, it ran, why you have built your pavement on *our* forecourt - and what are you going to do about it? - and, in particular, what's all this about rental and other conditions which relate to *our own land*? Should you dispute the matter further, please substantiate with proof that



The magnificent painting created by space artist Don Dixon, was generously presented to the Society by Mr. Douglas Arnold of Space Frontier Ltd. in June. It shows a Daedalus-type spaceship firing its second stage near a binary star system.

20 YEAR STINT

The Council were happy to mark 20 years of dedicated service to the Society by Ms S. A. Jones, the Society's Assistant Executive Secretary, with a token presentation of appreciation. Here Ms Jones is seen with the object of her choice, an antique French hand-painted Coffee Set by Engrand Maillard, fit to grace any dining table.

Missing from the picture is a beautiful antique silver-plated bon-bon dish, currently being restored.

It sounds fabulous but, in fact, it wasn't very costly - which goes to show that there is still a chance of picking up a bargain or two in the antique world.

Until recently Ms Jones carried the whole load of both *JBIS* and *Spaceflight* on her shoulders - she was also responsible for the whole of the typesetting (much of it undertaken voluntarily) of the Society's two fund-raising books, "Project Daedalus" and "High Road to the Moon".

Now, besides typesetting the whole of *JBIS*, Ms Jones is responsible for all matters affecting Office Management and also (in her spare moments!) runs the Society's film lending service.

you own the land.

The GLC backed down. Up came their pavement and down went our present railings.

Alarmed by a change in the pavement, the Local Council then charged in. "What," they demanded, "were we doing to their pavement?" or, at least - the pavement they looked after for the GLC.

They got the same treatment.

The Local Council backed off, too, so the fixing of the railings continued.

There was, however, a postcript.

When all was done, among the multitude of Inspectors visiting the property came two from the Historic Buildings Commission. *They* weren't satisfied with the railings: the reconstructed railings differed from those originally "protected" in one significant way.

The files showed the difference. The railings originally were decorated at intervals by large acorn finials.

This was something we knew nothing about, though subsequently we were able to locate a photograph which showed what they had originally looked like. Members might like to see it.

So there it is, we have our railings and our land back but, one day, we will need six acorn finials if we are to get things back to the way they once were.

NEW—LOOK SOCIETY TIES

In response to a number of requests, the Council has introduced an alternative type of Society tie, dark blue as before, but containing one central motif, i.e. our logo just below the knot.

The logo is identical in size to that which appears on the front cover of Spaceflight. It shows the central symbolic rocket among the stars surrounded by the name of the Society. The advantage of the new tie is that it is more readily identifiable with the Society than the former version which shows the logo only and which has to be viewed from close-up before detail can be made out (in any event it does not give our name).

The new-style tie is available for exactly the same price as the old i.e. £4.50 ($10) post free.

N.B. Where the new style tie is not specially asked for the "standard tie" will be supplied.

WELCOME!

Recently we had distinguished visitors at the BIS, Mr. Fred C. Durant and Mrs. 'Pip' Durant, who stopped off in London on their way home from Holland.

Fred, a long-standing Fellow of the Society, has been connected with rocketry frm way back. He joined the Bell Aircraft Rocket Group after the war, returned to the US Navy as Director of Engineering of the USN Rocket Test Station at Lake Denmark and has held numerous other positions in Aerospace since. A one-time President of the IAF, he joined the Smithsonian Institution in 1965 as Assistant Director and was Head of the Department of Astronautics at the National Air and Space Museum until 1980. Currently he is Consultant to a number of Space Museums both in Europe and the Far East.

Fred takes a good view of the Society's work. *"I regard the BIS as very important in my life,"* he says.

SOCIETY PUBLICITY

It is impossible to keep track of every reference to the Society which appears nowadays though enough examples have come our way of late to show that they are as numerous as ever. Much, if not all, of the credit for this is due to the enterprise of individual Society members.

As always, a number of activities stayed glued to the Launch Pad. Most frequent among these were requests from individuals seeking material and information for publication under their own names, without any credit to the Society, in the manner of the old Pavement Artist who used to scrawl "All me own work" by the side of pictures of dubious parentage.

Newspapers

Quick on the draw, so to speak, was Jon Levy, whose home contains a mass of complex equipment which enabled him to monitor broadcasts on the Shuttle flight and, incidentally, gain a mention for it, a photo and description of himself as a member of the Society in the *Hull Journal* of 9th April.

An even more substantial cannonade appeared in the *South London Press* for 23rd January. This emerged as a two-page centre spread concentrating on the Executive Secretary himself, complete with picture and with substantial references to the Society. It was very nicely done, even though it contained the unfortunate information that Len's trip to see the Shuttle launch was being financed by the Americans. Regrettably, it was not!

The *Sutton Borough Guardian* for May 14th, in a half page on Ken Gatland's new "Encyclopaedia of Space Technology" referred both to the Author and to Arthur Clarke, who had provided a foreword to the book, as leading members of the Society.

Down under, Don Wanson appeared in a regular column devoted to the film industry in *The Australian*, of 16th December 1980, which not only mentioned his association with the Society but described Don's plans for a new SF movie. Don has a shooting script in the final stages and mentions that he makes good use of both *JBIS* and *Spaceflight* as sources for supporting background ideas.

A letter from Simon Warrender, in the same part of the world, appeared in *The Australian Financial Review* dated 16th April. Simon advocates the establishment of an Australian Space Research Agency and quotes, with approval, the fact that the BIS first urged the creation of a UK Space Authority on the UK Government in 1965; a similar basic recommendation was made by the Royal Society in 1980.

Magazines

Magazine-wise we did even better.

Colin Ledsome prepared a write-up of the Society's Sixth Form Conference in *Engineering Design Education* for Spring, 1981, under the heading of "Engineering? What's That?" This ran to two pages and, usefully, included the Society's address. Mention of the same event also appeared in *Dynamics News*, the British Aerospace (Hatfield) staff magazine. A letter from Chris Viles appeared in *Building Design* for 3 April headed "For Spaced out Architects"; it pointed out that the skills of architects could be needed in space developments no less than those of any other group, and advocated that they join the Society. Our name and address followed!

Astronautyka, (No. 5, 1980), the magazine of the Polish Astronautical Society, also did us proud, using four photographs of the Society's new HQ Building, accompanied by a very nice writeup.

Sky and Telescope for January 1981 included a letter from Bill McLaughlin mentioning his JBIS article on "Prediscovery Evidence of Planetary Rings", while the front cover of *Sternzeit* featured a drawing of Daedalus and also added the Society's address. A further reference to us appeared in another American Astronomical publication, this time *Star and Sky*.

On a slightly different tack, but having the same effect, was the Society's half-page advertisement featuring Daedalus in *Cosmic Search*, (Fall, 1980) which echoed their advertisement in our own magazine. The same thing applied, of course, to our continuing advertisements in the *Journal of the British Astronomical Association*, with whom we have always enjoyed a long-standing cordial relationship.

Even miniscule publicity has its value. For example, the *University of Reading Bulletin* (No 138, Feb. 1981) mentioned that no less than three of the papers presented at the Society's Space Forum meeting in London on 23 January, were given by Reading Graduates.

Radio

The first Shuttle launch provided some useful radio publicity, for while *Columbia* was making its way back to Earth with Young and Crippen aboard on 14th April, listeners to London's major radio station, Capital Radio, were able to hear our *Space Chronicle* editor, Andy Wilson, providing a commentary on the flight. Andy was later joined by BIS member Guy Alimo and together they answered questions during a "Shuttle Phone-In".

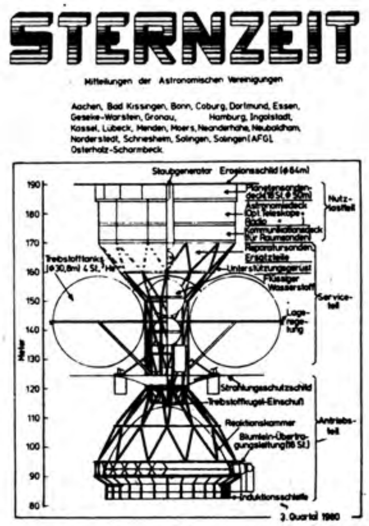
A SOCIETY FIRST

The Society broke new ground on 27 May when, for the first time, one of its meetings was chaired by a Lady Chairman, (or perhaps *Chairperson*?). The encumbent was Penny Wright, a Fellow of the Society with a long background in aviation electronics. Penny is now Senior Engineer with EMI Electronics and still logging up flying hours, work for which she was recently awarded the MBE.

Penny contributed many of the communications system ideas which appeared in Project Daedalus and is listed among the authors. A long-time student of the Open University, she is now rounding off a full and busy education with a course on ergonomics.

The building in the background is Buckingham Palace and not, as you might think, our new headquarters!

Society News/contd.



Cover of the space magazine *Sternzeit* which featured a drawing of Daedalus.

Andy made a second appearance later in the week, this time on London's LBC station, to discuss the future of space travel stemming from the first successful Shuttle flight. Both programmes gave ample publicity to the Society.

Bookbuffs

For bookbuffs, the publicity sheets of *The Hunting of Salyut 7* by Guy Alimo described him as an Associate Fellow of the Society. Tim Furness brought out a new book, *Man in Space*, which included the Society's address, while Master Ian Brown (11 years old) told us very firmly not to forget that we were also listed in *Spotters Guide to the Night Sky*.

The beautifully-illustrated *Cosmos* by Carl Sagan gave a short description of the Society and several Daedalus pictures on pages 203-206, while his forthcoming TV series with the same title (forthcoming to the UK, of course) referred both to the original BIS Moonship of the late '30's as well as to Project Daedalus in episode 8, with the title of "Travels in Space and Time".

Meetings, Displays & Exhibitions

Publicity can take surprising forms. One, for example, stemmed from the programmes arranged by the Central Office of Information for Overseas Visitors invited to the UK as official guests of the Foreign and Commonwealth Office. Since our Society has always warmly welcomed overseas visitors, it is no surprise to find ourselves listed among the principal places and organisations which such guests may ask to see included in the official itinerary for their stay.

The Society continued its regular programme of providing films to educational establishments throughout the country, sometimes helped by occasional listing in other magazines e.g. films in our list with Meteorological connections were listed in *Meteorology Film Review*.

Also on the education front was an unusual request, this time in the form of an appeal for support from the National Housewives Register Conference, though the title of their display, "What Price Progress?" was hardly encouraging. Support, however, was duly provided, as it was for a similar request emanating from the Librarian of the Bretton Centre in Peterborough, for material at an SF Convention in Sacramento, California requested by Don Robertson, and for help with a club for intellectually gifted children in Great Missenden, organised and run by their parents.

Clark Andrews, one of our American members, was also terse and to the point. "I mention the BIS at every lecture both astronautical and astronomical, that I give! How's that?" he asks. First rate, Clark, absolutely first rate!

SPECIAL ANNOUNCEMENT

A discussion meeting on the theme of

THE SOLAR SAIL RACE

will be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **17 November 1981**, 7.00-9.00 p.m.

The Space Technology Committee has organised this meeting to enable those interested to discuss the possibility of flying experimental solar sails in a race, the finishing mark being occultation by the Moon. The sails would be launched by Ariane IV and boosted by a common apogee motor to a few thousand kilometres.

Invited speakers will discuss the opportunity, the mass performance envelopes and general interfaces with the launcher.

Admission is by ticket only. Members should apply enclosing a stamped addressed envelope.

Among the most heart-wringing, *and* the most difficult to meet, are requests from hospitals, such as St. Lukes Hospital at Guildford, which wants to use the Shuttle as its next Christmas theme. They propose to decorate one long ward as a "runway". We did our best but, as ever, in the final analysis the Nurses will have to work all of the miracles.

Unsolicited Advertising

The number of unsolicited compliments about our HQ Building, often from complete strangers, remains quite remarkable. Many passers-by, unable to contain their curiosity any longer, knock on the front door to ask about both the building and the Society. Others, we are told, even accost our cleaning lady on the front doorstep in the early morning to gain the desired information. Some compliments reach us after having passed through two or three people on the way.

Many members take such trouble to see our building that we feel we owe it to them to try to improve it in every way and make their visit as interesting as possible. Thus, we were suitably flattered when one visitor asked to see our "Space Centre" - Cape Canaveral, look to your laurels!

All this is most encouraging, both to the Council and Officers of the Society, and to our members who contributed so much to make this substantial achievement possible.

CORRESPONDENCE

Voyager

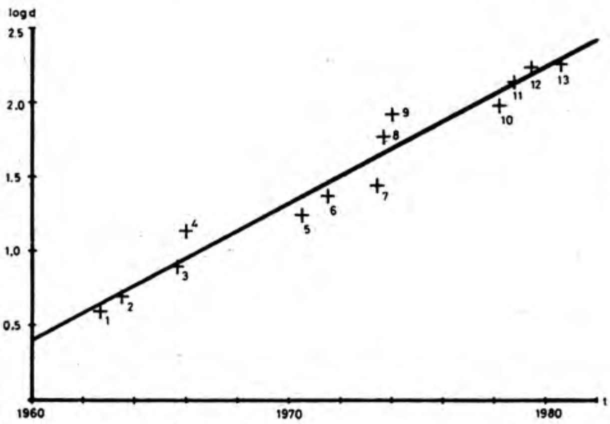
Sir, I would like to correct a small but important inaccuracy in the excellent article by J. K. Davies ('A Brief History of the Voyager Project') that appeared in the February 1981 issue of *Spaceflight.* Mr. Davies credits James Long of the Jet Propulsion Laboratory (JPL) with the first analysis of 'Grand Tour' trajectories which stayed clear of Saturn's rings. In fact, the effects of the Saturn ring barrier on Grand Tour trajectories were originally studied by Brent Silver of the Lockheed Missiles and Space Company in 1966. Dr. Silver's results were presented as Paper 67-613 at the AIAA Guidance, Control, and Flight Dynamics Conference in August 1967. A revised version of this paper entitled 'Grand Tours of the Jovian Planets' was published in the *Journal of Spacecraft and Rockets* in June 1968.

The investigations by Dr. Silver had a significant impact on JPL planning for the Grand Tour mission and were subsequently incorporated into the Voyager flight plan. Unfortunately, it is difficult to find any reference to Dr. Silver's contribution in the numerous JPL publications concerning mission analysis for the Voyager project.

R. W. FARQUHAR,
Mission Support Computing & Analysis Division,
Goddard Space Flight Center.

Manned Spaceflights

Sir, Plotting the duration, d, of flights holding the manned spaceflight record presents an interesting result. An exponential curve fits all of the points (except Gagarin and Titov) remarkably well. The diagram shows that log (duration) of the last 13 record holders is a linear function with a correlation coefficient of 0.978. Extrapolating this 20-year line over the next 10 years suggests that by 1991 we will have a 5 year flight.



The numbers of the diagram refer to:

1. Vostok 3
2. Vostok 5
3. Gemini 5
4. Gemini 7
5. Soyuz 9
6. Soyuz 11 - Salyut 1
7. Skylab 2
8. Skylab 3
9. Skylab 4
10. Soyuz 26/27-Salyut 6 (Romanenko/Grechko)
11. Soyuz 29/31-Salyut 6 (Kovalyonok/Ivanchenko
12. Soyuz 32/34-Salyut 6 (Lyakov/Ryumin)
13. Soyuz 35/37-Salyut 6 (Popov/Ryumin)

Dr. I. ALMAR
Hungary.

Thanks

Sir, May I take this opportunity of saying how much I enjoy the Societ's publications. I normally receive only *Spaceflight* each month, but since I find many articles in *JBIS* interesting (especially those of a nature as usually contained in the *Space Chronicle* issues), I am grateful that members can have an opportunity to buy them.

I can well imagine what a load you and other staff have to bear, but rest assured that your efforts in supplying such high quality publications to members are well appreciated!

GETHYN D. JONES.
Gwynedd, Wales.

What's in a Name?

Sir, I would like to comment on the possibility of changing the Society's name, about which many letters have been written. I doubt if you could find more apt initials than B.I.S. as not only do they sum up wha the Society stands for but they also stand for "Britain In Space" - I hope we can all live long enough to see that come true.

PAUL KARADZAS
Paraguay.

Help!

Sir, Can anyone help me? I would like to know the frequency used for transmitting TV pictures to Earth from Salyut 6. The Soviet half of Soyuz-Apollo used 463 MHz but I think Salyut 6 employs a different frequency.

M.D. OSLENDER
Germany

Salyut 6 crews

Sir, Now that the mission of Salyut 6 is so advanced, I believe that it is possible to comment on the crews originally chosen (before the failed docking attempt of Kovalonok and Ryumin aboard Soyuz 25 in October 1977) for long-duration stays aboard the space station. These crews were:

1. Kovalonok + Ryumin
2. Romanenko + Ivanchenko (backups to crew 1)
3. Lyakhov + Lebedev
4. Popov + Sawinych

After the failure of Kovalonok and Ryumin, the second crew were to be sent up but, because of possible damage inflicted on Salyut 6 by the Soyuz 25 docking attempt, Grechko, a specialist in that area, replaced Ivanchenko. The Soyuz 25 crew were given a later flight. The crews now became:

1. Romanenko + Greckho
2. Kovalonok + Ivanchenko
3. Lyakhov + Ryumin
4. Popov + Lebedev
5. ? + Sawinych

Because of these changes, Sawinych lost his commander and perhaps a flight to the station. A fifth long-stay crew was formed because the station has remained operational longer than expected; Kovalonok was the first commander available with long-stay experience (Romanenko was involved with Interkosmos flights), so he was chosen. The first three flights went normally but crew 4 above had to be changed because Lebedev injured his knee during training. It seems logical that

Correspondence/contd.

he would be replaced by his backup , which should have been Sawinych but because the latter was training for a Soyuz-T flight, Ryumin stepped in and took his place.

The long-stay crews thus became; (with their backups):

1. Romanenko+Grechko/Kovalonok+Ivanchanko
2. Kovalonok+Ivanchenko/Lyakhov+Ryumin
3. Lyakhov+Ryumin/Popov+Lebedev
4. Popov+Ryumin/(Kovalonok+Sawinych)
5. Kovalonok+Sawinych

PETER STUIT
Netherlands

It's a Gift!

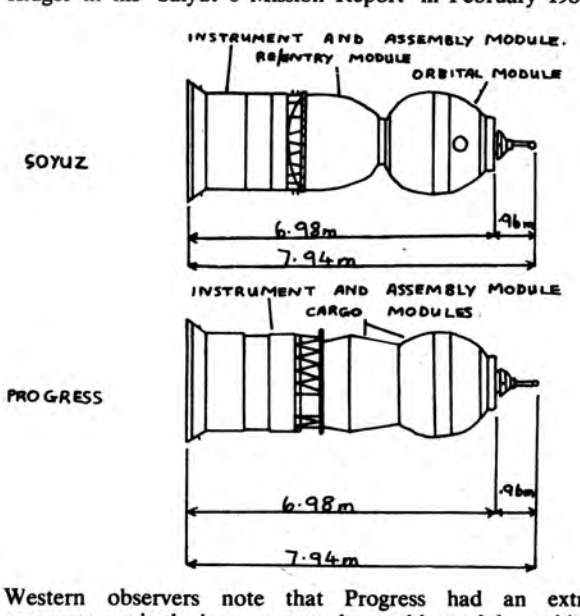
Sir, My sincere thanks to you for the requested literature in connection with Essex County Council's residential courses for gifted children. I am delighted with what you have sent - the magazines are visually appealing to children, and the written content of some of the articles will, I am sure, be enough to stimulate even the most gifted child!

MRS P.N. SMITH,
Essex.

Soyuz And Progress

Sir, Attempts have been made in *Spaceflight* over the last two years at putting lengths to the Soyuz and Progress spacecraft used in Salyut docking missions, often quoting east European sources (sometimes accepting these without question). I have attempted to determine the lengths of both spacecraft using photographs and accurate side views in books and magazines, often *Spaceflight* itself.

The length accepted for Soyuz and quoted in *Spaceflight's* 'Satelite Digest', is 7.5 m. When the Progress cargo spacecraft was introduced, the Soviets gave its length as about 8 m, later giving more a specific length of 7.94 m, as shown by Neville Kidger in his 'Salyut 6 Mission Report' in February 1980.



Western observers note that Progress had an extra compartment in the instrument and assembly module, making it seem longer than Soyuz. Taking the length of Progress minus its docking probe (when docked to Salyut) as 6.98 m, the probe must be 0.96 m, long. The Soyuz length, therefore, must be 6.54 m when docked to a Salyut, accepting that both craft use the same type of probe and that Soyuz is 7.5 m long.

However, from the photograph of Soyuz/Salyut on p.62 of the February 1981 *Spaceflight* and of the side view of the ASTP Soyuz in *Rendezvous in Space* [1] came to the conclusion that a length of 7.5 m for the Soyuz ferry is incorrect; indeed, it is the same length as Progress at 7.94 m. The 7.5 m Soyuz was the Soyuz 19 ASTP craft used in 1975 and accepted as the standard Soyuz by some sources.

The Progress cargo craft, while having an extra compartment in the instrument and assembly module, has a shorter orbital module than Soyuz, and the centre cargo module is shorter than the comparable re-entry module used on Soyuz.

PHILIP MILLS
Nottingham

REFERENCE

1. Lebedev and A. Romanov, 'Rendezvous in Space: Soyuz Apollo,' Progress Publishers, Moscow.

Burner 2

Sir, Further to Andrew Wilson's article (*Spaceflight*, May 1980) and Stephen Graham's letter (*Spaceflight*, March 1981), the following information on the use of the Burner 2 upper stage may be of interest. The answer to Mr. Graham's speculation as to the type of Atlas booster used for the Atlas-Burner 2 launches is that both versions were used. The 1968 launch used the Atlas SLV-3A and the 1972 launch used the less powerful Atlas F. The SESP/STP designations for these flights were SESP P68-1 and STP P72-1, respectively. OV5-8, as given by Mr. Wilson, was only one of ten payloads carried on P68-1, which would have resulted in a record twelve separate satellites if the launch had been successful. (One payload consisted of four separate satellites and two payloads would have remained attached to the Burner 2.) The correct designations of the remaining non-DMSP Burner 2 payloads are: SESP P67-1 for Aurora/Secor in 1967; SESP P70-1 for the IR test payload in

1971; and SESP S70-4 for the three calibration spheres carried with the last block 5A, also in 1971 [1]. The launcher for P67-1 was a forerunner of the Burner 2A configuration in that it had three stages. The third stage was a purpose-built spin-stabilised structure enclosing a Thiokol TE-M-516 (Star 13A) motor. This stage was unusual in that the two payloads were mounted on the sides rather than the top of the stage.

As Mr. Graham states, the Block 5D launches to date have used a three-stage vehicle. The second stage, which like the third is incorporated into the integrated payload/launch system, uses the ubiquitous Thiokol TE-M-364-4 (Star 37E) motor [2]. The heavier Block 5D-2 series (first launch due this year) was originally intended to use this same upper-stage configuration on Thrust-augmented Thor (SLV-2A) boosters, but this was changed last year to the Atlas F with the second stage omitted — the same combination that has already been used for the Tiros N series [3]. The Star 37 family of motors has seen a very wide variety of uses in various configurations. To Mr. Wilson's list of Surveyor, Burner 2, Delta, Centaur and Block 5D can be added the Japanese N-1 and N-2 vehicles, Fairchild's PTS and SVS upper stages for the Atlas F, the Voyager propulsion module, and apogee motors for FLTSATCOM and Intelsat 5 geostationary satellites.

Finally, I can only add a third voice to Messrs. Wilson and Graham's comments about the accuracy of the various satellite launch lists. Even in *Spaceflight* there is a tendency to call any small solid upper stage a Burner 2, even one that does not use a Star 37 motor (see February 1981). The Solwind (STP P78-1) launcher in fact used yet another of the Fairchild solid rocket upper stage family, the Orbit Insertion System with a TE-M-616 (Star 27) motor [4].

G. R. RICHARDS
Sutton, Surrey

REFERENCES

1. *Astronautics and Aeronautics*, September 1976.
2. Aeronautics and Space Report of the President — 1977 Activities.
3. *Aviation Week & Space Technology*, 29th September 1980.
4. *Journal of Spacecraft and Rockets* **16**, 5 September/October 1979, pp. 338-342.

Space Astronomy in the USSR

Sir, Having returned from a scientific visit to the Soviet Union concerning astronomical observatories and the Space Research Institute, I would like to report on one or two matters which may be of interest to the Society.

Arriving at Nauchny, the scientific village of the Crimean Astrophysical Observatory, I became acquainted with several Soviet projects in addition to visiting the existing telescopes.

For example, I saw an 80cm (31.5in) mirror made for a Soviet UV satellite to be launched in 1983. There was also talk of a plant to be built for a 4m (157.4in) mirror, having to do with a Soviet space telescope to be launched at the end of this decade.

In Pushino, I met one of the leading designers of Soviet parabolic radio telescopes. He is working on a new millimetre radio telescope of 36m (118ft) diameter which employs a new method for which he is applying for a patent. (He apologised for not being able to explain the technique.)

In Zelenchukskaya — the location of the RATAN 600 radio telescope — I was informed that the main radio astronomical project being studied is a 1,000km (620 mile) array of paraboloids for interferometry work which can be kept in phase to provide useful data.

At the Space Research Institute in Moscow I was fortunate enough to work with the interferometry group for five days. I saw a photograph of a mockup of a 3m (9.8ft) dish operating on $\lambda = 1.35$cm to be launched into space and work as an interferometer in conjunction with ground stations. The experimental KRT-10 erected by cosmonauts Vladimir Lyakhov and Valery Ryumin from the Salyut 6 space station had a reflector of 10m (32ft) diameter. It operated on 18cm.

Finally, during a visit to the Space Exhibition in Moscow, I saw a mockup of Progress 5/Salyut 6/Soyuz 32 and was surprised to note that the Soyuz had solar panels and a toroidal fuel tank.

M. Q. HASSAN

The Root of all Evil?

Sir, I cannot agree with Charles Radley (*Spaceflight* p.186 June 1981) that the matter of the money system in space colonies is irrelevant. In pointing to Cambodia as an example of what happens when money is abolished he does have a valid point. Indeed, if such an imposed alternative system were tried anywhere else in the world it would have the same disastrous result. But where a community is mentally, morally and, above all, spiritually geared to total co-operation, and dedicated to an agreed aim, an alternative system would work, and indeed has already done so for limited periods. I am refering to Antartic and Arctic expeditions in the early years of this century when the explorers were completely cut off from what we are pleased to call civilisation. In these circumstances food and all other necessities, including the means for recreation, were provided because they were needed, not for gain. Thus the man who caught fish automatically handed them over to the general commissariat instead of demanding payment. The man who could mend clothing did so, not for gain, but because it was required.

There was also an island (I think it was Tristan da Cunha) colonised by the British, where the people lived quite happily without a money system. When it was introduced the whole society disintegrated into the jealousies, competing cliques and the plain greed which we regard as the norm.

A non-money system in a space colony must presuppose a high moral and spiritual purpose in the colonists. A random selection of average 'civilised' Earthmen *at this moment* is hardly likely to qualify. But there are signs of a moral and spiritual evolution. I do urge BIS members to consider that space colonisation will not only require better and better technology but also better and better people. Otherwise we shall merely spread wider in the Universe our 'constant bickering' (Peter Molton in the same issue of *Spaceflight* as Mr. Radley's letter) and our disastrous money system which no-one can understand or put right when it goes wrong. In all my 60 years there never was a time when there was not a financial crisis somewhere. One may argue that the system is all right, it's only the people who mess it up. Maybe, but if people were right we wouldn't need money anyway.

All right, keep your money system on space colonies, and you'll have exactly the same problems there — unless the colonists are a better lot than we are!

JOHN ALISON
Warley

Home Thoughts From Afar

Sir, The only reason I wish I still lived in London is that I would like to be able to attend meetings at the new Headquarters . . . the meetings all look so interesting nowadays!

T. HASSALL
New Zealand

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

NOTICES OF MEETINGS

MAKE IT A DATE

SPACE '82

THE FUTURE OF MANKIND

This will be a new type of Event for the Society, designed with participation by our members in the provinces and abroad (and their wives!) very much in mind. So why not join us at the Picadilly Hotel in London, W.1. on 12th-14th November 1982?

Meet and hear leading personalities in many fields of astronautics and enjoy a range of lectures and other events which will provide an outstanding and most enjoyale weekend.

An outline of the events currently scheduled appears below:

12 November (Friday)

16.00-18.30 Registration

20.00 Buffet Supper with welcoming addresses, L.J. Carter (Executive Secretary): *Meet the Society;* Introducing some of our Guests of Honour

13 November (Saturday)

9.30-10.15 Guest Speaker: *Journey to Halley's Comet*

10.15-11.00 Guest Speaker: *A Vision of the Future*

11.00-11.20 Coffee

11.20-12.40 Sessions in parallel:
Space Communications: The Universe at our Fingertips.
Space: The New Spirit of Adventure

12.40-14.00 Lunch

14.00-16.00 Sessions in parallel:
Into Deep Space
The Energy Problem: Will Solar Power Satellites Provide The Answer?

16.00-16.30 Tea

16.30-18.00 Guest Speaker

20.00 Dinner (dress informal)
Speeches by Guests of Honour
The Society, soon 50 years old - A Look Ahead

14 November (Sunday)

9.30-11.00 Parallel sessions:
Space Education: Key to the Future
Industrialisation: Space in the 21st Century

11.00-11.20 Coffee

11.20-12.00 Guest speaker:
Exploration of our Solar System

12.00-12.40 Guest speaker
12.40-14.00 Lunch
Closing speeches

There will be plenty of opportunity to see displays and exhibits and to talk about career opportunities.

Registration forms will be available from the Executive Secretary shortly. Applicants should enlose a reply-paid envelope.

36th Annual General Meeting
The 36th Annual General Meeting of the Society will be held in the Tudor Room, Caxton Hall, Caxton Street, London, SW1 on Saturday **26th September 1981,** commencing 3.00 p.m.

AGENDA

1. Report of the Society's Affairs for the year to 31 December, 1980.
2. To receive the Society's Balance Sheet and Accounts for the year ended 31 December 1980 and the Auditors' report thereon.
3. Appointment of Auditors.
The present Auditors, Fraser Threlford & Co. have merged with Norton Keen & Co. and the combined firm will practice under the name of Fraser Keen.
4. To elect four members of the Council of the Society. In accordance with article 15 the following Members of the Council will retire at the meeting:

G. V. Groves	W. R. Maxwell
W.F. Hilton	G. V. E. Thompson

5. General Discussion
6. Any other business.

A member who cannot personally attend the meeting may appoint by proxy, some other person, who must be a member of the Society, to attend and vote on his/her behalf, subject, however, to the provisio that a proxy cannot vote except on a poll.

Study Course

Theme: **REMOTE SENSING**

A course of eight evening meetings on the above topic, including a visit, will take place during the 1981-82 session. Details are as follows:

30 September 1981	What is Remote Sensing? by Dr. J. R. Hardy
28 October 1981	Platform, Sensors and Data Processing by Dr. J. R. Hardy
11 November 1981	Data Classification and Interpretation by Dr. J. R. Hardy
25 November 1981	Space Oceanography by Dr. J. O. Thomas
9 December 1981	Visit to the Laboratory for Planetary Atmospheres, Department of Physics and Astronomy, University College, London, accompanied by Dr. G. E. Hunt, 6.30-8.00 p.m.
6 January 1982	Remote Sensing: Needs & Applications in Developing Countries by Dr. E. C. Barrett
17 February 1982	Remote Sensing by Landsat and Weather Satellites by Dr. R. Harris
10 March 1982	Evening of technical films on Remote Sensing

The venue will be the Society's Conference Room at 27/29 South Lambeth Road, London, SW8 1SZ. Lectures will run from 7.00-9.00 p.m. Course Fee £5.00.

Application forms for registration are available from the Executive Secretary, Please send s.a.e.

Continued on outside backcover

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Continued from inside back cover

First Night

An opportunity for new members of the Society (and their guests) to meet members of the Council and Officers of the Society will occur on **7 October 1981,** at the Society's HQ Building, 27/29 South Lambeth Road, London, SW8 1SQ, 7.00-900 p.m.

It will be an informal evening in which members can hear about the History and Activities of the Society, see a space film and have an opportunity for a short guided tour of the Building.

New members who would like to attend are invited to apply in good time, enclosing a reply-paid envelope.

Lecture

Title: **RECENT ADVANCES IN SPACEFLIGHT**
by P.S. Clark

A review of space activities throughout the world which have taken place during the past twelve months to be held in the Golovine Conference Room, Society HQ 27/29 South Lambeth Road, London, SW8 1SQ, on **14 October 1981.** 7.00-9.00 p.m.

Admission by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **OBSERVATIONS OF THE ATMOSPHERE OF VENUS FROM THE PIONEER ORBITER**
by Dr. F.W. Taylor

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **18 November 1981,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show

Theme: **THE MAKING OF AN ASTRONAUT (PART II)**

Further stages in the development of manned space voyages will be illustrated in the following film programme which will be screened at a meeting to be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **2 December 1981**, 7.00-9.00 p.m.

The programme will include the following

(a) The Hard Ones

(b) Gemini 11 - Quick Look

(c) Spaceship Skylab - Wings of Discovery

(d) The Mission of Apollo-Soyuz

(e) Space Shuttle - Overview

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **STARS - THE SOURCE OF LIFE**
by C.A. Whyte

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **20 January 1982,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **THE RETURN OF HALLEY'S COMET**
by M.J. Hendrie

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **10 February 1982,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show

Theme: **SPACE SATELLITES**

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **24 February 1982,** 7.00-9.00 p.m.

The programme will include the following:

(a) Landsat: Satellite for All Seasons

(b) Navigation Satellite

(c) Discovery in Space

(d) Streetcar (OGO)

(e) Electric Power Generation in Space

(f) Orbiting Solar Observatory

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Symposium

Theme: **SATELLITE FLIGHT DYNAMICS**

A two day Symposium will be held in the Rutherford Appleton Laboratory lecture theatre, Chilton, Didcot Oxon on **3-4 March 1982.**

The Symposium will include the following topics:

1. Orbit determination and prediction techniques
2. Attitude control systems
3. Modelling of the space environment
4. Satellite dynamic behaviour
5. Satellite control and stabilisation
6. Large flexible arrays
7. On-board computers

If the response is sufficient, the symposium will be extended to a third day (5th March 1982).

Offers of papers are invited. Registration forms and copies of the programe will be available from the Executive Secretary in due course. Please enclose a stamped addressed envelope with request.

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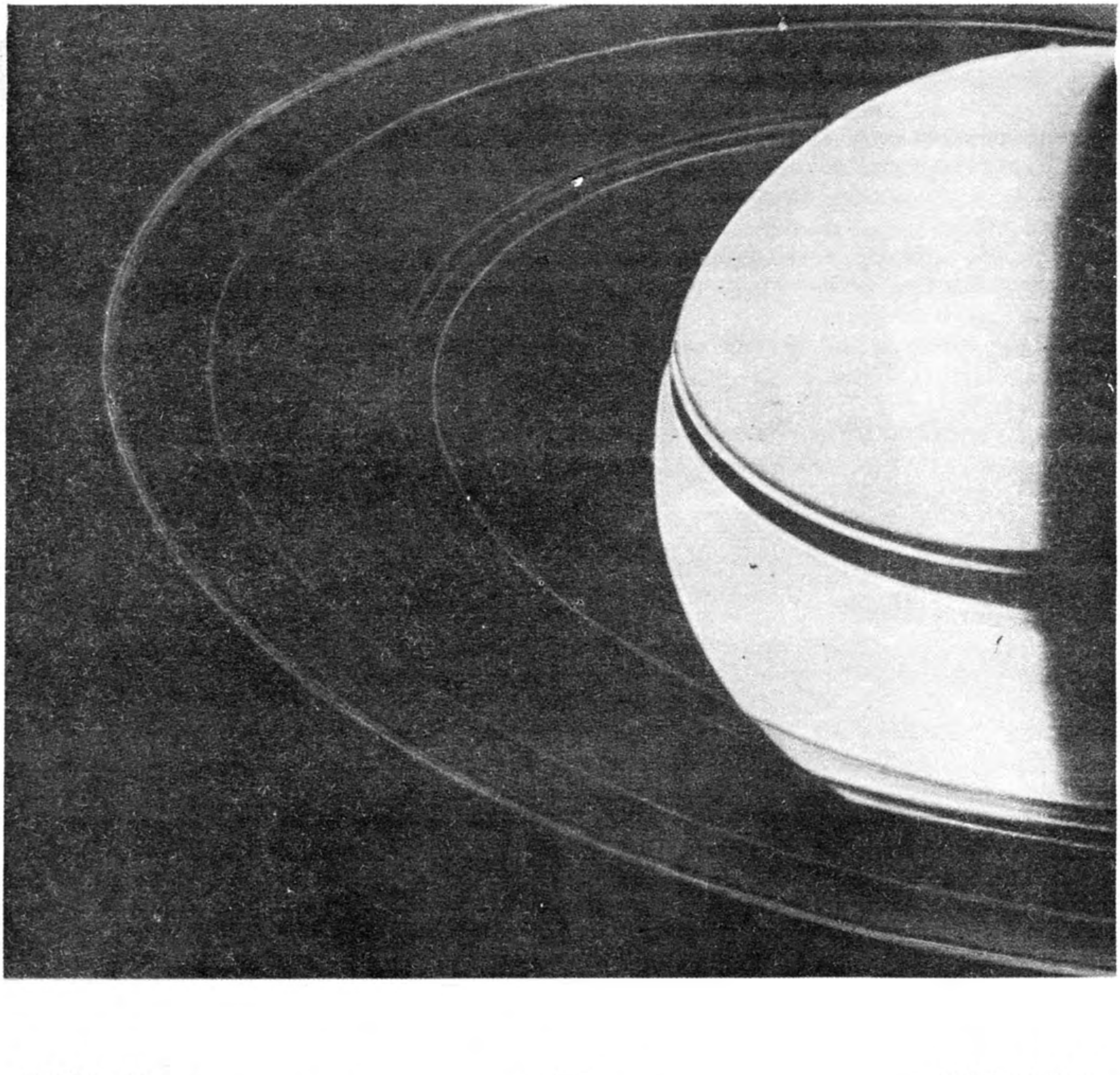
SPACEFLIGHT



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COVER

One of the first pictures returned by Voyager 2 from Saturn after its camera platform fault had been rectified following fly-by. The craft is now on target for an encounter with Uranus in 1986.

Jet Propulsion Laboratory

MILESTONES

July 1981

15 Shuttle engine 2108, under test at a NASA facility in Missouri, shuts down after an injector failure. The test was part of series to uprate the engines to 109% of their normal full power level.

21 Twelfth anniversary of the first manned Moon landing. In 1969 astronauts Armstrong and Aldrin guided LM-5 *Eagle* to a safe touchdown in the Sea of Tranquility.

21 Meteosat 2, launched by Ariane L03 on 19 June, reaches its intended position at 0 deg. longitude in geosynchronous orbit. The meteorological satellite, spinning at 100 revs/min, is to be tested on station and the first weather pictures from its radiometer will reach the ground by the end of the month.

27 *Columbia* begins two days of integrated tests, powering up its system and checking compatibility with its payload. The tests began three days late because of electrical problems with the Remote Manipulator System.

August 1981

3 The two Dynamics Explorers (see *Spaceflight,* August-September, p.223) are launched into incorrect orbits because the Delta launch vehicle's second stage failed to fire for its full duration. The mission is expected to be completed, however.

4 Engineers at KSC begin modifications to the Shuttle launch pad to reduce the pressure wave which will hit *Columbia* during SRB ignition. The shock in the first mission last April was four times greater than expected.

5 Space Services Inc's Percheron rocket is destroyed during a static test of its 60,000 lbf engine.

7 The Intercosmos-Bulgaria 1300 satellite is launched into a 500 miles orbit from Baikonur. The Meteor-type craft carries 12 Bulgarian experiments for investigations of the Earth's ionosphere and magnetosphere.

10 GMS 2, a synchronous meteorological satellite, is launched from the Tanegashima Space Centre by the first operational NII booster. The satellite will be moved to 140 deg. East to replace the failing GMS 1, launched in July 1977.

12 *Columbia* is mated to its External Tank and Booster in the VAB.

MEMBER SERVICES

Sweatshirts	*p. 315*	New-Style Society Ties	*p. 327*
T-Shirts	*p. 318*	Magazine Binders	*p. 330*
Membership Cards	*p.325*	Library Opening Times	*back cover*

VOYAGER 2 AT SATURN

In the early hours of 26 August Voyager 2 swept past the planet Saturn in a close encounter. Pictures of the rings and satellites of higher resolution than those from Voyager 1 were obtained, until the craft emerged from behind the planet and revealed that its camera platform was jammed. This problem was solved and Voyager went on to complete its mission.

The magnificent successes of Voyager, like those of Viking, shows what can be achieved in the exploration of the Solar System. If all goes well, Voyager 2 will reach Uranus in January 1986 and Neptune in August 1989.

Introduction

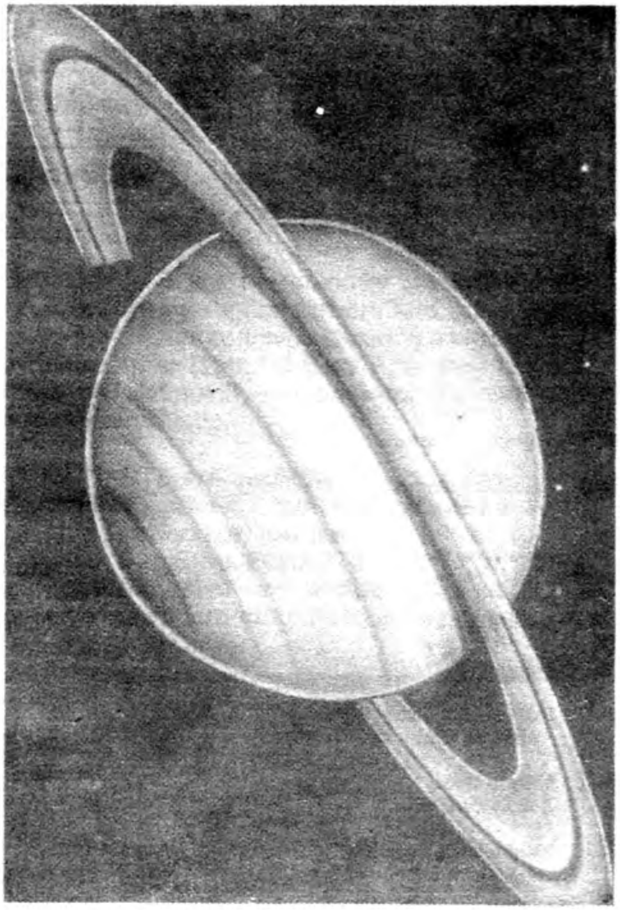
Before Voyager 1's Saturn encounter, project officials planned that Voyager 2's studies of Saturn, developed over two years, would be revised according to scientific data returned by the first spacecraft. So many unexpected and unexplained phenomena were observed by Voyager 1 in the Saturnian system that Voyager 2 was extensively reprogrammed in flight.

Saturn's rings, for example, were found by Voyager 1 to be even more complex in their structure and dynamics than previously believed. Conversely, science objectives for Voyager 1's study of the large satellite Titan were achieved, so time that might have been devoted to further photographic coverage of Titan by Voyager 2 was used instead on obtaining new images of the rings, planet and other satellites. Additional remote sensing of Titan, however, was planned.

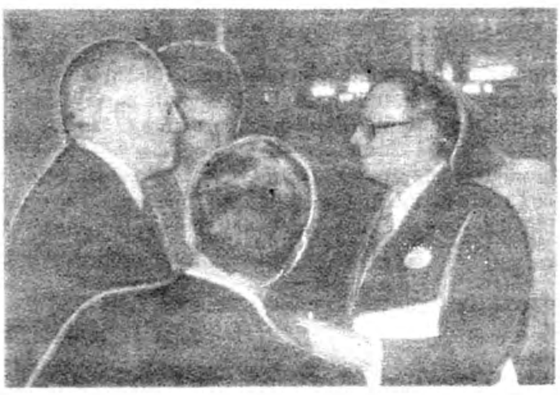
More than 18,500 photos of Saturn, its rings and satellites were to be taken by Voyager 2 and by the time the post-encounter period ended on 28 September both Voyagers should have returned more than 70,000 photographs of Jupiter, Saturn, their rings and satellites.

During Voyager 2's flight over Saturn's ring plane on 26 August, the spacecraft's photopolarimeter (located on the movable scan platform) was aimed at the star Delta Scorpii, on the opposite side of the rings and more than 989 light years away.

Measuring the star's light as it flashed through the ring material provided data on the number of ringlets, their densities and widths, and the widths of the gaps between them. After the fly-by, scientists estimated the number of rings as high as perhaps 100,000, contrasting with less than 10 a few years ago.



Saturn viewed on 4 August. The three bright spots are Tethys, Dione an Rhea, in order of proximity to the planet.



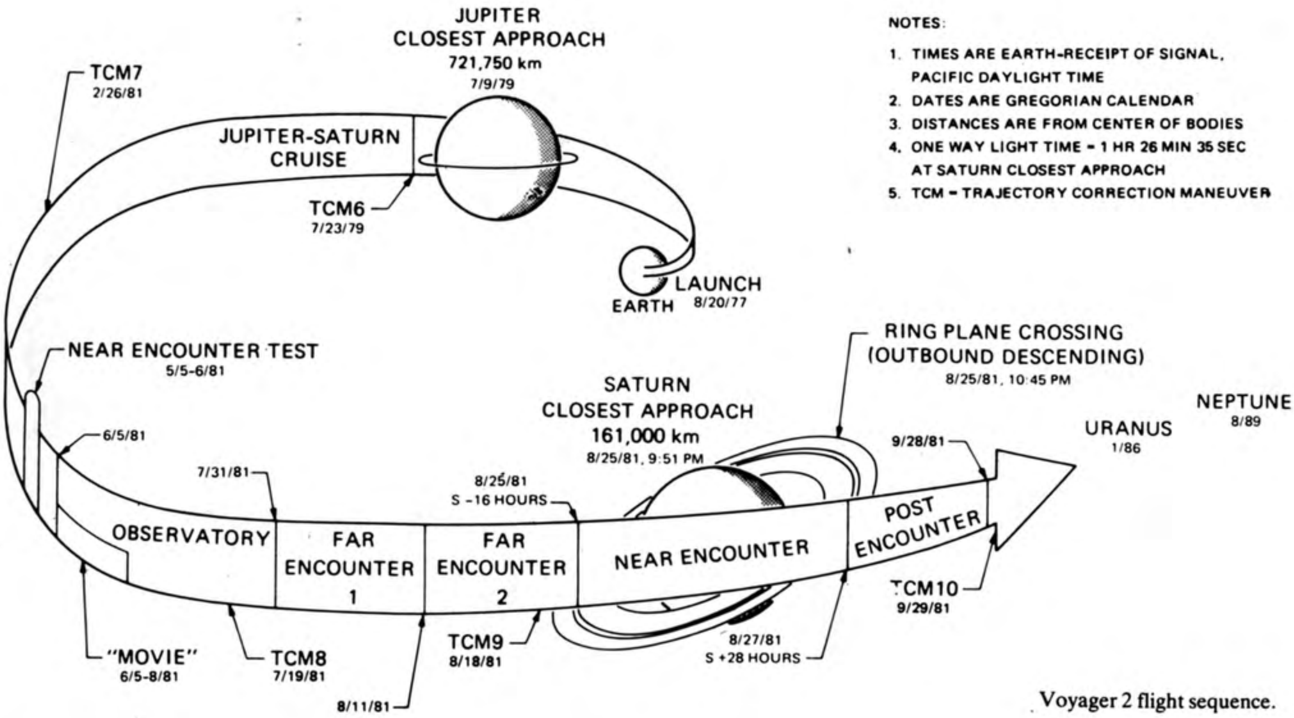
On 26 August representatives of the BIS Council and Programme Committee were among an invited audience at the US Embassy to see the first extensive views of Saturn from Voyager 2. This provided an opportunity to see a programme beamed by satellite from the Jet Propulsion Laboratory in California, and to meet engineers from Motorola, the host company which was responsible for the communication equipment aboard the probe. L. to R. are L.J. Carter, Peter Conchie, Tony Lawton and Counsellor Bloom of the Embassy.

Then trouble struck. As Voyager emerged from behind the planet at about 0700 GMT controllers at the Jet Propulsion Laboratory found that the scan platform carrying the two cameras, UV and IR detectors, and photopolarimeter had jammed. Observations of the rings, planet and moons were lost as engineers strove to work out what had happened. Pictures *were* obtainable but only by using precious attitude gas to move the entire craft, fuel which would be needed for the Uranus and Neptune encounters in the years to come. Project Scientist Ed Stone commented, "We were fortunate that the platform didn't stop a few hours earlier. We've completed most, if not all, of the major scientific objectives."

The platform was unjammed by turning it with the motor at higher speed than usual but engineers still held back from using it immediately while it was checked out thoroughly.

The second occulation of a star by the rings occurred about nine hours after Voyager passed Saturn. As it looked back at the planet, the star Beta Taurii should have been tracked by the photopolarimeter for about 40 minutes, as the star flashed through the F- and outer A- rings. The expected resolution of ring material was as small as 100 m (328 ft.).

Voyager 2 closely studied the spoke-like features of the B-ring discovered by Voyager 1. The spokes emerge from the planet's shadow and seem to dissipate after a few hours, possibly the product of fine material suspended above the ring plane as a result of electrostatic charges. As the spacecraft moved through the ring plane, the cameras photographed the



Voyager 2 flight sequence.

rings edge-on, searching for signs of possible clouds of small particles elevated above the rings, and the planetary radio astronomy experiment searched for electrical emissions originating near the spokes. Preliminary analysis indicated that Voyager may have actually passed through a ring.

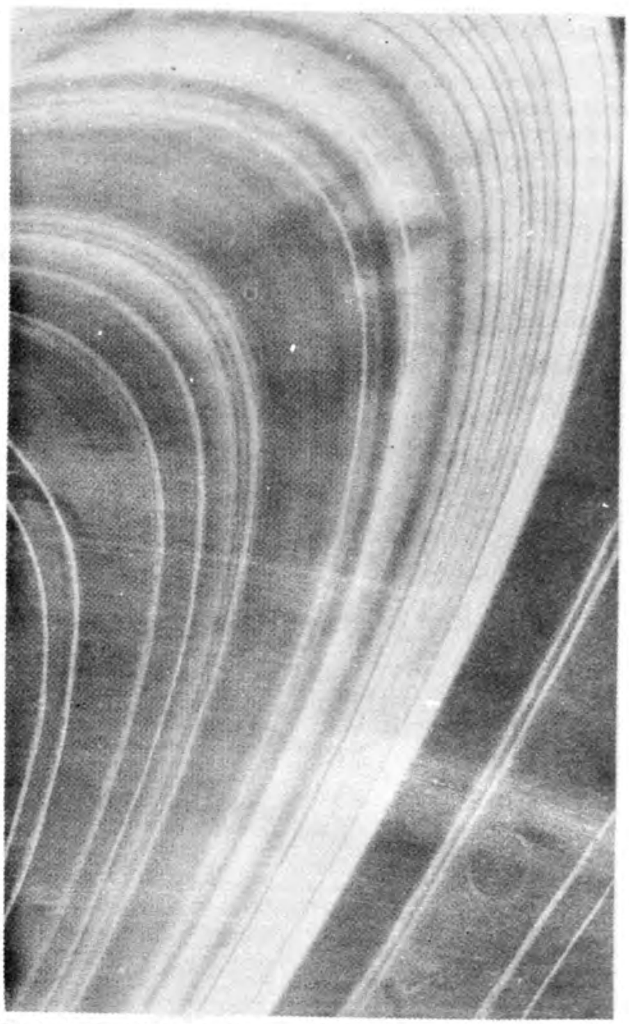
The apparent twisted and clumped appearance of two of the three visible strands of the F-ring were to be subjected to pseudo-stereo imaging, in which photographs taken from different angles were to be combined for a three-dimensional view of the ring. Sequences of images should reveal whether the structure of the F-ring changes with time. Preliminary analysis, again, showed up some surprises. Instead of the expected three braids scientists saw up to 14, causing them to reconsider the theory that two nearby moons were shepherding the material together.

As Saturn was the final planetary encounter for Voyager 1, its trajectory was designed to maximise the science return from the encounters with little regard to where the spacecraft would travel afterwards. For Voyager 2, the aim point at Saturn was defined by the requirement to continue the trajectory to Uranus. The arrival time at Saturn, however, was selected to allow closer approaches to several moons viewed more remotely from Voyager 1.

Voyager 2 crossed the potentially hazardous ring plane only on its outbound leg (Voyager 1 crossed the ring plane at different distances both inbound and outbound) at about 111,800 km (69,500 mi) from the cloud tops, just 1200 km (745 mi) outside the orbit of the G-ring which is only approximately located by a single Voyager 1 photograph. (Voyager engineers had expected the spacecraft to clear the G-ring by 1,200 km or 745 mi.)

The ring plane crossing occured while the spacecraft was blocked from Earth view, so reacquisition of communications was the sign of a safe crossing.

Voyager 2 passed 23,000 km (14,300 mi) closer to Saturn than did Voyager 1. In addition, the spacecraft made closer approaches to the satellites Enceladus (87,000 km), Tethys (93,000 km), Hyperion (480,000 km), Iapetus (900,000 km), and Phoebe (2,080,000 km). Enceladus is especially interesting since Voyager 1 photos showed little evidence of surface features, indicating there may be dynamic geological processes


Spoke features in the B-ring, seen 22 August.

occurring. Voyager 2 photographed Enceladus and Tethys with high resolution and took measurements as they eclipsed the Sun. Voyager 2's photopolarimeter is in good working order, so it was able to look for aerosols on Titan, something Voyager 1 was unable to do.

Before Voyager 1's arrival at Saturn last year and the discovery of several hundred "ringlets," the rings were thought to consist of perhaps six individual rings; from planet outward, they are the D-, C-, B-, A-, F- and E-rings. The dusty G-ring, which was first photographed by Voyager 1, is the innermost ring orbiting about 109,000 km (68,000 mi) above Saturn's cloud tops.

Before encounter, Saturn was known to have at least 17 satellites. Three were discovered by Voyager 1, and two in ground-based observations since Voyager 1's encounter.

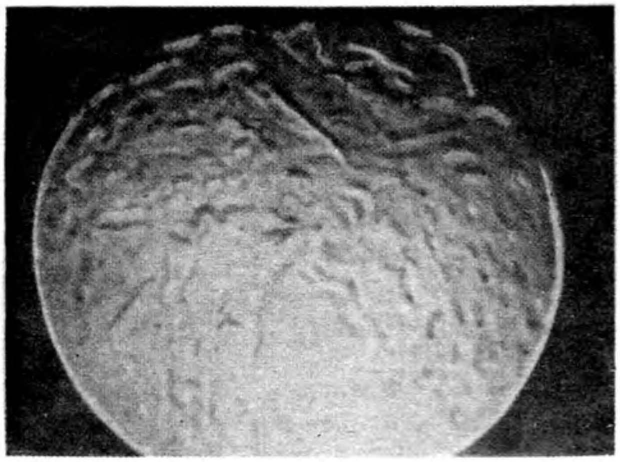
The innermost satellite is temporarily designated 1980 S28 and is about 40 by 20 km (25 by 12 mi) in diameter. It orbits 76,970 km (47,800 mi) above the cloud tops just outside the A-ring.

The next two satellites are 1980 S27 and 1980 S26. These were believed to be shepherding moons, maintaining the edges of the braided F-ring. They are both approximately 200 km (124 mi) in diameter and orbit 79,070 km (49,130 mi) and 81,370 km (50,560 mi), respectively, from Saturn's cloud tops.

Two small moons, 1980 S3 and 1980 S1 share an orbit about 91,120 km (56,600 mi) from the cloud tops. 1980 S3 is 90 by 40 km (55 by 25 mi) in diameter; 1980 S1 is 100 by 90 km (60 by 55 mi).

A satellite sharing the orbit of Dione is 1980 S6, about 160 km (100 mi) in diameter. It orbits about 60 degrees ahead of Dione at a distance of 318,270 km (197,760 mi) above the cloud tops.

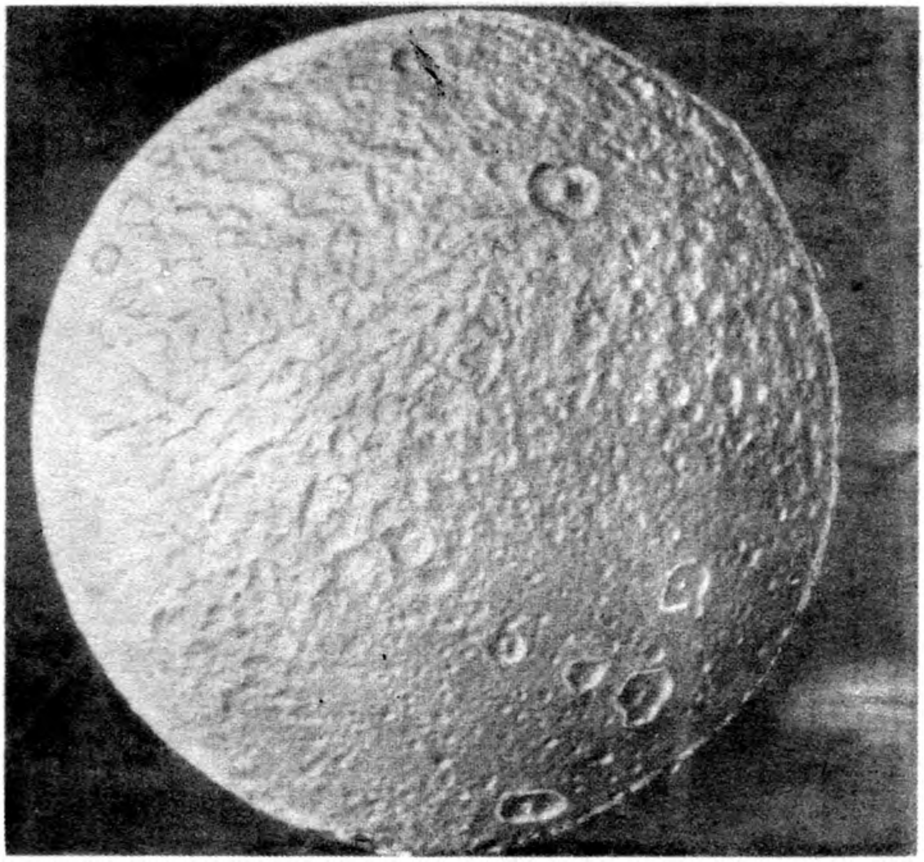
The two satellites discovered in ground-based observations occupy Tethys' orbit; 1980 S25 orbits about 60 degrees behind Tethys, while 1980 S13 orbits about 60 degrees ahead. They appear to be about 30 to 40 km (20 to 25 mi) in diameter.



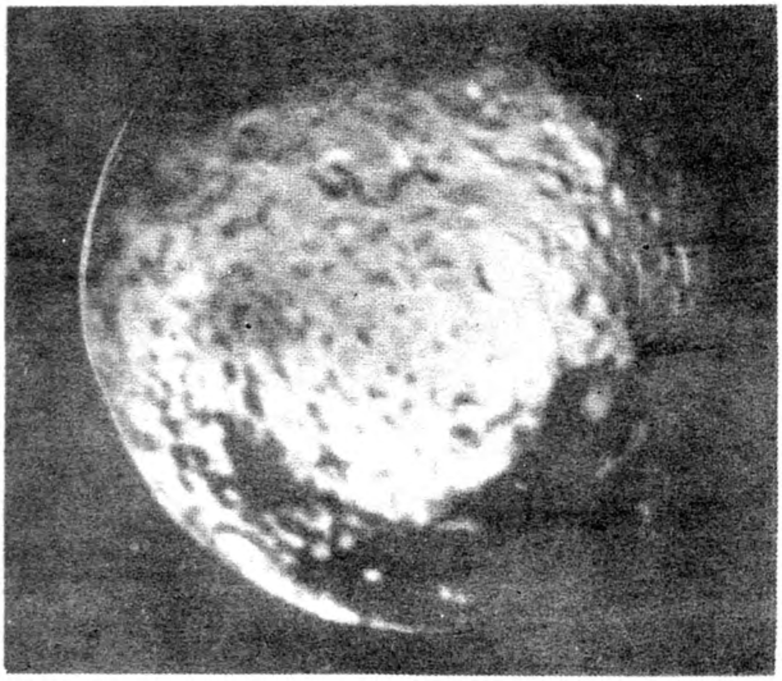
A distant view of Tethys, showing the remains of a large crater on the icy surface.

Each Voyager carries telescope-equipped television cameras, a cosmic ray detector, an infrared interferometer spectrometer, a low-energy charged-particle detector, magnetometers, a photopolarimeter, a planetary radio astronomy receiver, a plasma detector, plasma-wave instrument and ultraviolet spectrometer. Each spacecraft is comprised of 65,000 individual parts.

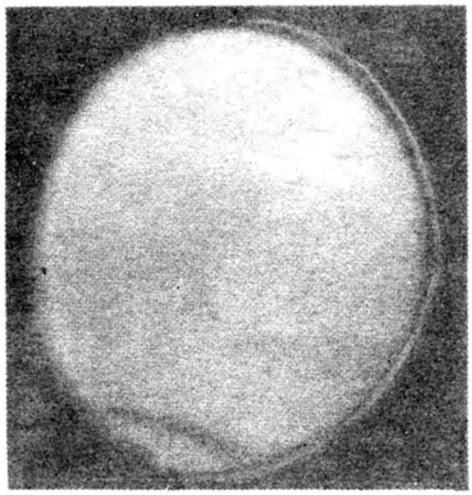
Both Voyagers will escape the Solar System at velocities of nearly 59,550 km/hr (37,000 mph). The two spacecraft may reach the heliopause within 10 years. Even at these speeds, however, more than 40,000 years will pass before Voyager 1 flies within 1.6 light years of the star AC+793888 near the constellation of Ursa Minor; in 358,000 years, Voyager 2 will pass within 0.8 light years of Sirius.



This Voyager 2 photograph of Tethys shows objects about 5 kilometres (3 miles) in size and is one of the best images of the Saturnian satellite returned by the spacecraft or its predecessor, Voyager 1. Voyager 2 obtained this picture on 26 August from a range of 282,000 km (175,000 mi). A boundary between heavily cratered regions (top right) and more lightly cratered areas (bottom right) is very similar to boundaries on the moons Dione and Rhea, indicating a period of internal activity early in Tethys' history that partially resurfaced the older terrain. The large crater in the upper right lies almost on the huge trench system that girdles nearly three-quarters of the circumference of the satellite. The trench itself is seen in this image as a linear set of markings to the lower left of the crater. The trench, several kilometres deep, is indicative of a cold, stiff ice crust at the time of its formation. Formation of this trench system could have resulted from the expansion of Tethys as its warm interior froze.

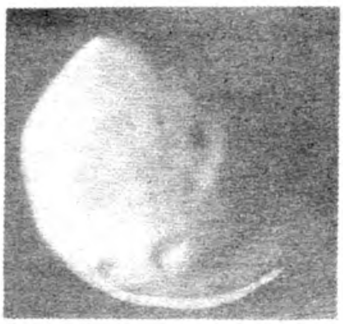


Iapetus seen on 22 August at a distance of 1.1 million km (680,000 mi). This image, which shows features as small as 21 km (13 mi) across, has been processed to reveal as much detail as possible of the bright, icy regions of the northern trailing hemisphere. The number and forms of impact craters here appear similar to those of the heavily cratered surfaces of the inner icy satellites (such as Rhea and Mimas) photographed by Voyager 1. This similarity suggests an ancient crust dating back to the early history of the Solar System. Iapetus is noteworthy for the very dark material (seen here in the lower and right-hand parts of the picture) that apparently covers the satellite's ice crust primarily on its leading hemisphere.

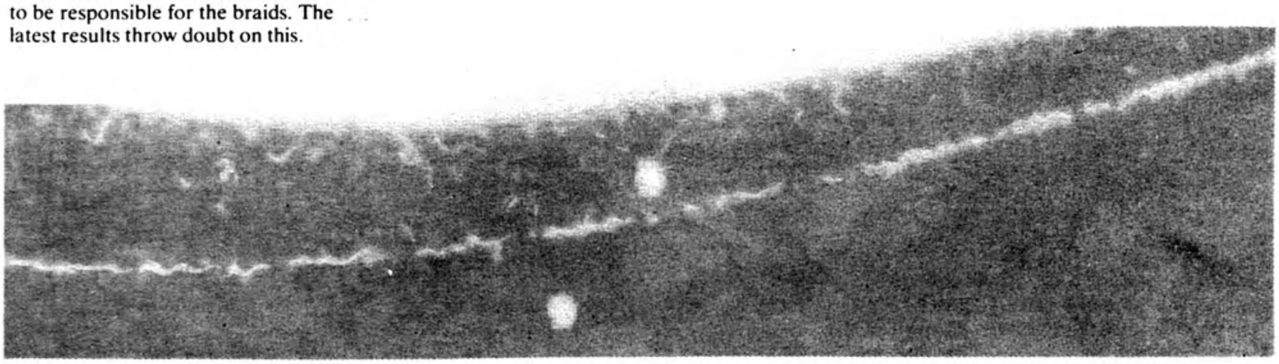


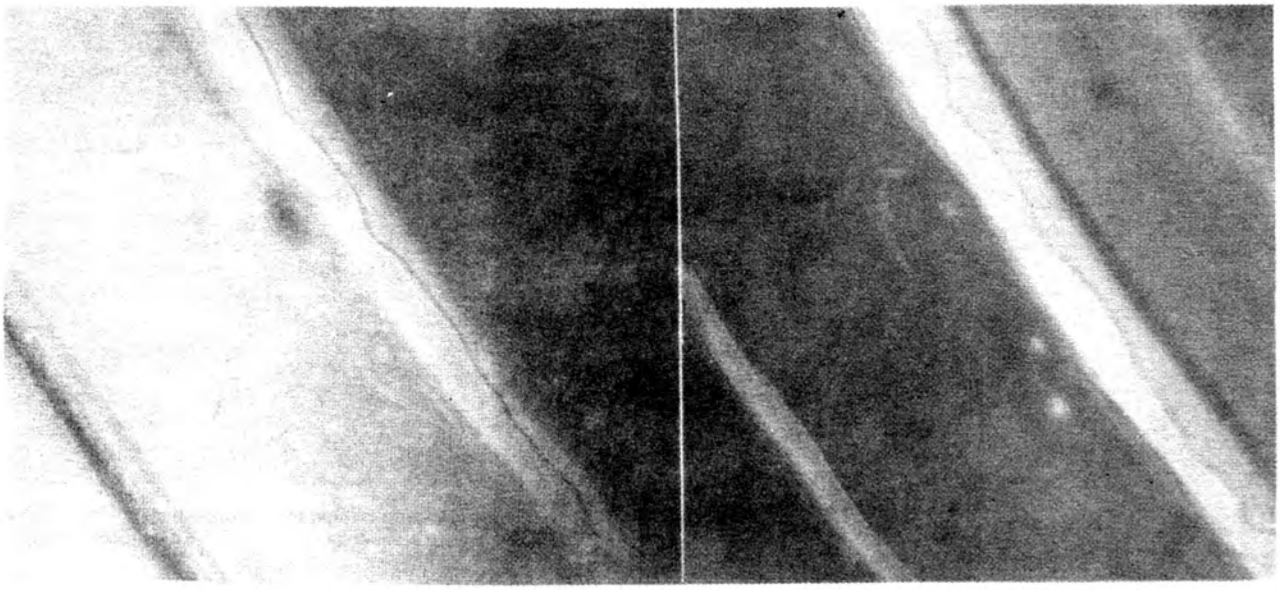
Markings evident in the atmosphere of Titan, with a dark polar collar at high northern latitudes. Voyager did not find an ionosphere.

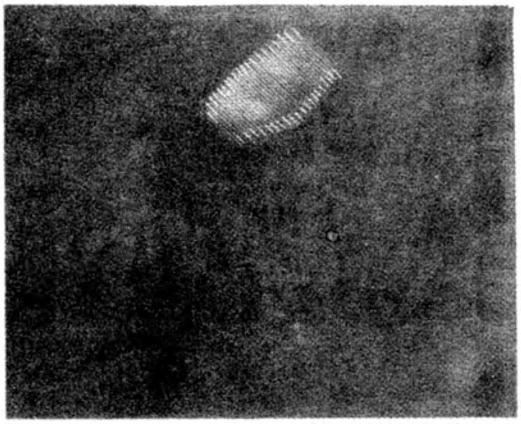
The B and C-rings seen at a distance of 2 million mi, with the planet's body barely visible at upper right.

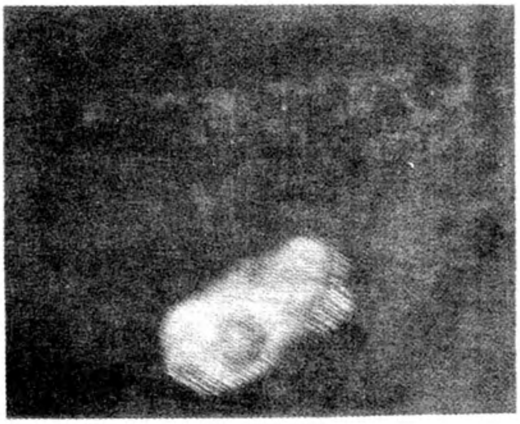


Above: Satellite 1980 S27, the inner moon of the F-ring. *Below:* the two moons closely connected with the F-ring. Before the latest encounter scientists had believed the satellites to be responsible for the braids. The latest results throw doubt on this.

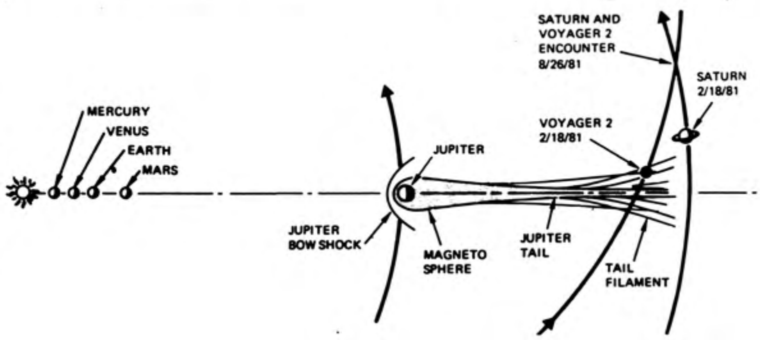








Top: Two images taken on 19 August, that on the left through a green filter, the other through violet. The two storms (bright spots) are clear in violet but barely visible in the green. *Above:* Two views of Hyperion, taken 12 hours apart on 23 August, show it to be very irregular and cratered. Its long axis should point towards Saturn for stability but it may have been struck recently. *Above right:* The northern hemisphere observed in green on 15 August with a resolution of 100 km. The wavy band at 47 degrees latitude marks a westerly jetstream. *Right:* On 18 February Voyager 2 detected a filament of the Jovian magnetotail stretching almost to Saturn's orbit.



TUNNELLING OUR MOON

By Dr. D. J. Sheppard

Introduction

The idea of underground colonies on the Moon is familiar to us through works of fiction such as "The First Men in the Moon" by H. G. Wells. In this book the Grand Lunar commented "upon the strange superficiality and unreasonableness of man who lives on the mere surface of a world, a creature of waves and wind, and all the chances of space". Later writers on spaceflight have given serious consideration to using natural caves to house a colony (Fig. 1); but as far as is known no-one has yet looked at the prospects for using normal tunnelling techniques to excavate a purpose-built colony.

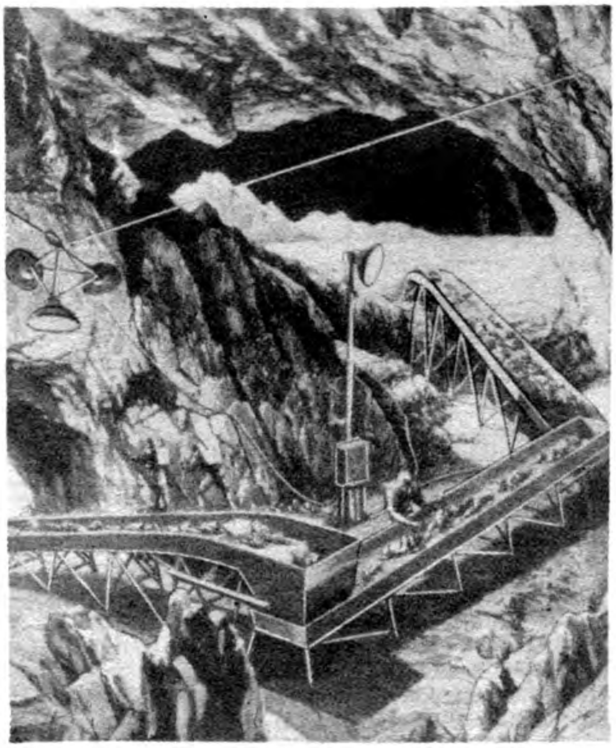


Fig. 1. Making a lunar cave suitable for habitation, as depicted by R. A. Smith (the picture can be seen on p. 92 of the Society's *High Road to the Moon*).

The Scope

Below thirty metres or more of moonrock, a colony would be structurally and thermally stable and protected from solar radiation. The bursting pressure of a breathable atmosphere would be balanced by gravitational stress in the rock. Provided that structural integrity is maintained, an underground colony offers a wide-ranging improvement over any surface construction.

It may come as a surprise to learn that most of the technology of underground colonies has already been proved. The hard igneous rocks of Sweden provided an ideal site for civil defence installations. Experience gained in this way showed that underground facilities are generally cheaper and safer than their surface equivalents. Underground construction is now big business in Sweden and other countries favoured with suitable rock. Examples of completed projects include nuclear power stations, self-contained towns for emergency use and huge oil storage tanks. Caverns of 3 million cubic metres, as large as the Vehicle Assembly Building at Cape Canaveral, are now common. Any type or scale of tunnelling needed for a lunar colony has almost certainly been tried and proved on Earth.

We are fortunate to have a rocky uninhabited Moon. Tunnellers on Earth have to do the best they can with ground conditions at locations decided by the customer. Why else would anyone want to work in quicksand below rivers, near-boiling water within mountains or in soft ground leaking poisonous and explosive gas? Lunar tunnellers will be spared these hazards because the Moon is dead, and for once they will be able to choose a site to please themselves.

From the results of Apollo it is thought that the lunar Highlands are largely made of Syenite, an igneous rock similar to granite. It so happens that granite is the ideal rock for excavating caverns and tunnels, so the Highlands should house the first colony. The basaltic rocks of the lunar Seas are less suitable although not out of the question.

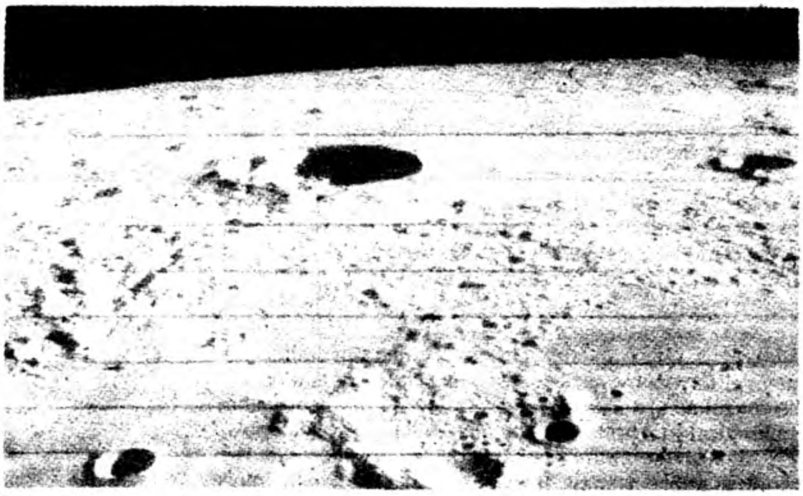
How much room is there for underground colonies? The answer is astonishing. The deepest mines on Earth reach 3840 m, which scales up to 23 km (14 miles) under lunar gravity, assuming that the rock is as strong as its terrestrial equivalent. A layer this thick over the Moon has a volume of 8.8×10^{17} cubic metres (212 million cubic miles). All of this rock is in principle available for excavation. Assuming that our far-off descendants manage to honeycomb one percent of this volume, the total floor area of the colony would be 3.5×10^{15}

MOON EXPEDITIONS

Fig. 1a. How long will it be before we go back to the Moon? The last Apollo expedition left in 1972 and the Americans have no plans to return. The Russians seem to be hinting that they are more interested in going to Mars rather than the Moon.

Either way, new space vehicles will have to be constructed to do the job.

Europe's plans this decade may include the unmanned POLO (Polar Orbiting Lunar Observatory) which could possibly discover frozen pockets of water at the lunar poles - an incentive for locating bases there.



square metres (1360 million square miles) of normal room height. This is 93 times the Moon's surface area, 24 times Earth's land area, and equivalent to 2100 *million* large orbital colonies such as the Stanford Torus. Reduce the estimates as much as you like to eliminate conditions that are unsuitable for current methods, although probably quite acceptable to future engineers: the scope is undeniably awe-inspiring.

Tunnelling Techniques

These figures show that there is no shortage of sites for lunar colonies. Our tunnellers can be very choosy about the rock in which they build the first. The ideal material would be a near-surface mass of granite-like rock, without faults or fractures. Although most of the Moon's surface is covered with broken rock, it seems reasonable to expect that suitable strata do exist.

Any type or scale of tunnelling needed for a lunar colony has almost certainly been tried and proved on Earth.

We merely have to find them. Several of the Apollo photographs do in fact indicate exposed bedrock of this type; one example is at Hadley Rille.

Unbroken granite is an ideal material for the following reasons:

1) The technology of tunnelling it is simple and well-proven.
2) Properly-shaped excavations do not need lining or structural supports.
3) The rock is inert over geological timescales.
4) Enclosed air or water will not leak away.

Hard rock is tunnelled by means of explosives packed into holes made by pneumatic or hydraulic drills, the rubble being loaded on to dump-trucks or conveyors for removal. This method is versatile enough to be applied to any shape or size of excavation. The machinery is simple and robust, and the scale of operations can be tailored to available manpower.

Since the rock containing the colony will be airtight and self-supporting, any pressurised bridgehead can be extended using exactly the same technology as on Earth. The advantages are obvious in terms of economy, reliability and assured results. Although new technologies such as rock-melting or laser-drilling may become feasible, we would be unwise to rely on them initially. In order to establish the bridgehead, it will be necessary to excavate from the surface, working in the hazardous environment of Space. This phase of the work will be referred to as "external" tunnelling. It will require special, electrically-powered machinery which is less productive than the tools perfected for working in an atmosphere.

When the bridgehead tunnel has been excavated horizontally into a mountainside and an airlock installed, the major tunnelling work will begin. Figure 2 shows the sequence

Underground accommodation costs one-fiftieth as much as its equivalent on the lunar surface.

of operations involved in the subsequent "internal" tunnelling. This illustration could equally well be used for a terrestrial textbook, since the sequence is identical. The apparently distinctive feature — the use of an airlock — is in normal use for pressurised excavation below water level. The drilling machinery is of standard pattern, either hydraulic or pneumatic, the open-cycle exhaust being collected and reused within the tunnel. In order to reduce total costs, it will probably be economical to replace steel by lighter aerospace materials, the greatly increased purchase price being outweighed by the reduction in transport mass. It is unlikely that the combination of drill steel and tungsten carbide bits will be superseded in the near future, and these will need regular reconditioning or replacement. The rubble loader and dump trucks will be electrically powered, in line with current practice for excavations with limited air supply.

The choice of explosive deserves close attention, since it is a major consumable as well as a potential source of danger. Dynamite and gelignite are favoured on Earth because of their strength, but unfortunately they give off toxic gases and are too unstable to transport through Space. A much better explosive for the Moon would be the less powerful Ammonium Nitrate, which explodes according to the equation:

$$2NH_4NO_3 \rightarrow 2N_2 + 4H_2O + O_2 + 55.4\,\text{kcal}.$$

It will be noted that the explosion products are all substances required on the Moon. Ammonium Nitrate is non-toxic, stable in vacuum, insensitive to shock and also happens to be a crop fertiliser. Since the use of it would produce nitrogen, water and oxygen, it seems reasonable to discount most of the cost of importing it. It will be assumed that 90% of the mass of explosives is recycled as resources for the colony, the other 10% being losses, packing and primer needed to ensure correct detonation.

The Cost of Lunar Tunnelling

Internal tunnelling can be costed with fair reliability because it is so similar to normal practice. External tunnelling is less predictable, but certainly more expensive. The Table shows the parameters used in the cost estimates summarised in Fig. 3. These values have been averaged from the experience of

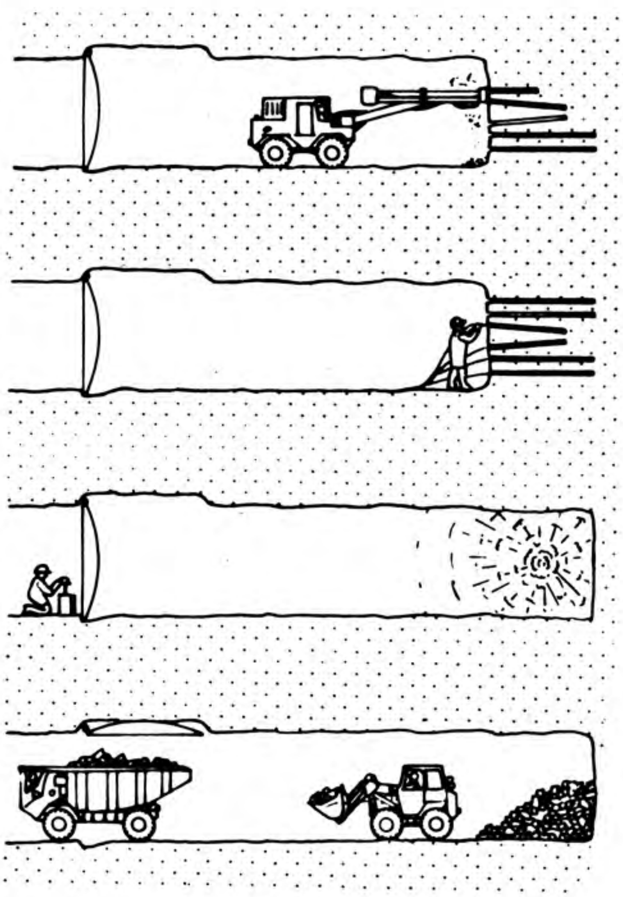
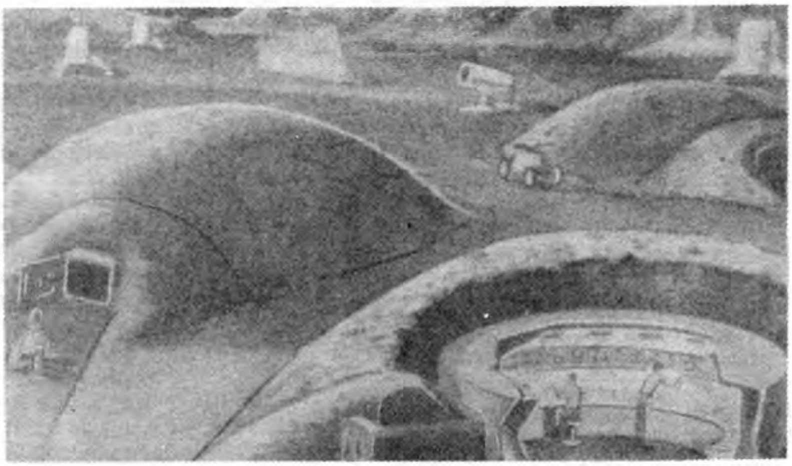


Fig. 2. Tunnelling sequence. *Top to bottom:* drilling holes in rock face; charging holes with explosives; detonation; clearing the rubble.

SURFACE BASES

Fig. 2a. Permanent lunar bases were included in space planning in the 1960's as part of the follow-on to the initial lunar landings. They usually included plans to land pre-constructed units on the Moon ready for surface emplacement with a coating of soil to act as protection against micrometeoroids. This is a 1969 concept at the height of Apollo's prestige. As space programmes in general began to fall from favour the idea of lunar bases was dropped although a permanent US space station is a possibility for later this decade.



similar jobs on Earth.

The main difference from terrestrial conditions will be the lower lunar gravity. This would appear to be entirely beneficial because it makes load-carrying easier and also reduces the effects of most accidents. Accepting that lunar gravity is unfamiliar, however, it will be assumed that productivity is initially reduced by a lunar penalty factor of between one and three. The more controllable use of consumables has been given a lesser penalty factor of between one and two. When the colonists gain more experience in lunar conditions, their efficiency should equal or surpass what is normal on Earth; but this optimistic assumption has not been used in the present cost estimates.

Figure 3 relates tunnelling cost to two critical variables: the cost of transporting mass between Earth and Moon, and the degree of self-sufficiency achieved by the construction base. Lunar-produced items are not free, of course, since they require extra machinery and manpower. Lacking details of these requirements, it is not possible to cost them exactly. As an approximation, it will be assumed that the cost of lunar manufacture is factored up from the cost of low-technology items on Earth, the factor being equal to the ratio between man-costs on Moon and Earth.

After equating all the parameters, the costs obtained have been doubled before inclusion in Fig. 3. This doubling follows normal practice in representing work in addition to basic excavation, such as surface finishing, leak sealing, local strengthening, and the installation of permanent air-locks. The graphs in Fig. 3 are for excavations without an atmosphere. The addition of this would increase costs by about one third. Two transport costs have been quoted, representing the high and low boundaries of the costs to be expected in the early stages of lunar colonisation. The establishment of a large, viable colony would, of course, encourage lower transport costs, with further reductions in the cost of tunnelling.

Figure 3 shows that underground accommodation costs only one fiftieth as much as its equivalent on the lunar surface. Comparing the tunnelling costs in Fig. 3 with the cost of buildings on Earth, it will be seen that lunar accommodation will be between 10 and 200 times as expensive. In round figures, tunnelling undertaken by a small, early moonbase might be expected to cost $10,000/m^3$, which would allow a colonist to be housed for a few hundred thousand dollars. A mature lunar colony would reduce this cost by a factor of ten or more.

These costs are encouragingly low, but they become really exciting when time is added to the equation. When valuing a factory or other accommodation it is normal accounting practice to write off the construction cost over its useful life. For example, a workshop may be written off linearly over 40 years, since after that time it will need replacing or renovating to make good the effects of weather damage and material decay. Underground accommodation is not subject to any similar deterioration, especially on the Moon. Inspired by disaster movies, one might imagine earthquakes bringing the roof down on the colonists. In fact terrestrial experience shows that tunnels are unusually resistant to seismic assault, being capable of withstanding ground accelerations of 0.2 g without damage. This corresponds to a major earthquake of 10^{22} ergs, roughly magnitude 6.8 on the Richter scale, whereas the Moon releases only 10^{15} ergs of seismic energy in a complete year. Barring man-made destruction and cosmic catastrophes, the only ageing factor will be the slow atmospheric breakdown of rock into clay particles. Large natural caverns on Earth last tens of thousands of years in limestone; well-built lunar caverns in strong igneous rock can be expected to last much longer. Assuming a lifetime measured in thousands of years, it is apparent that the annual write-off cost for lunar accommodation will probably be cheaper than the cost for your

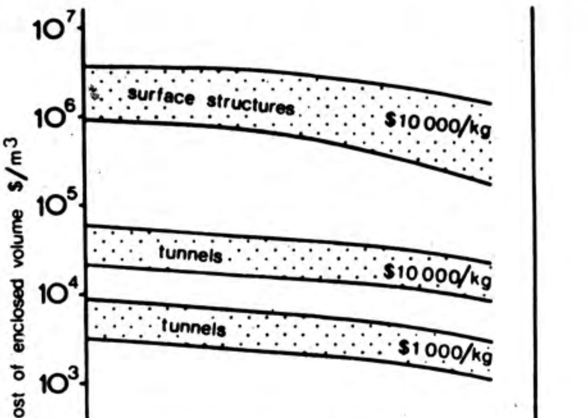


Fig. 3. Cost of enclosed volume.

Table of Cost Parameters

Mass of accommodation at construction site	7 tonnes/person
Mass of consumables	1.7 tonnes/person/year
Cost of tunnelling hardware, including a contribution towards R & D	$1,000/kg
Cost of consumables on Earth	$5/kg
Cost of low-technology hardware on Earth	$10/kg
Life of construction site accommodation	10 years
Tour of duty for construction crew	2 years
Life of tunnelling equipment	16,000 hours
One-way transport cost, Earth to Moon	$10,000/kg initially $1,000/kg later
Cargo equivalent for return flight	1,200 kg/person
Labour required	⅓ man-hour/m³
Tunnelling machinery (aerospace materials)	8 tonnes/worker
Consumption of explosives (ammonium nitrate)	1.6 kg/m³
Consumption of bits and drill steel	0.1 kg/m³
Lunar penalty factors: labour and machinery	1 to 3
explosives and drills	1 to 2

By drilling deep enough to the hotter regions of the Moon it should be possible to satisfy a colony's energy requirements independent of the day-night cycle.

Energy could perhaps be stored in superconducting magnets suspended in toroidal tunnels.

home on Earth. A worst-case lifetime of 40 years would still allow annual costs one quarter of those for office space in central London. Remember that this is the result of work by an early moonbase; the conclusions are even more favourable if reasonable extrapolations are assumed in tunnelling technology and lunar resources.

The Promise

The economics of an underground lunar colony are in many ways analogous to those of the European settlements in America. Land is cheap but communications are difficult and expensive. The first priority is to achieve the maximum degree of self-sufficiency in people and materials. The following ideas are based on this philosophy. They will be developed further in future articles, but are noted here to illustrate the promise.

1) A series of connected caverns and tunnels would house the colonists, their factories and farms. Illumination would be chiefly by sunlight and Earthlight ducted from surface collectors. Warmth and power would come from the Moon's internal heat, supplemented by solar energy.

2) Deep colonies would be invulnerable to all weapons and natural catastrophes except internal sabotage or a cosmic collision. The survival of mankind would be assured if such refuges existed.

3) Loss of air would be made negligible by the use of multiple air-locks emptying into a series of large, low-pressure reservoirs pumped on the cascade system. Leakage through solid rock is, of course, practically zero, especially if a lining membrane is used.

4) Using the fact that deep tunnels would be much hotter than those near the surface, the internal heat of the Moon could be harnessed to provide heat, power and natural air-conditioning. Scaling up the deepest drill hole on Earth, it should be possible to reach the geological discontinuity at 60 km, where the temperature 500°C+ higher than on the surface would fuel the colony independent of the day-night cycle.

5) Energy could be stored by two methods depending on tunnelling technology. The first method stores energy by pressurising air or other gases in large caverns. This principle has already been proved in the German Huntorf power station. The second method of energy storage is in superconducting magnets supported by toroidal rock tunnels. This principle has been researched extensively, and its implementation requires an underground site such as the Moon provides in abundance.

6) A long tunnel would house the lunar accelerator, its launching end being aimed up an inclined shaft to the surface. An enclosed site has great advantages in ease of construction and maintenance within an environment that can be sealed and pressurised. The alignment and stability of the accelerator would also benefit from the solid foundation and thermal shielding that a tunnel affords.

7) Zero gravity could be achieved for a few minutes within a parabolically-profiled tunnel containing a production line running on tracks. This facility would replace many of the functions of expensive orbital plant.

8) All types of hazardous processes could be carried out in safety within isolated caverns. The long, maintenance-free life of lunar tunnels makes them the best available site for disposing of nuclear wastes from Earth.

9) Some scientists believe that the Moon contains large caverns full of volatile materials at moderate depths. Deep tunnels would give access to these resources and their containers. Wherever veins of useful minerals exist, it will be doubly economical to combine mining with extension of the colony network.

Conclusions

An attempt has been made to demonstrate that underground colonies on the Moon are not only technically feasible but also economical and fruitful in their promise. This study has been based on existing hardware and well-proved methods. The cost parameters come from what has already been achieved, not from some hoped-for product of future technology. As far as can be ascertained, the only "hopeful" assumption is that the Moon has somewhere on its vast surface a mass of unfractured rock large enough to contain the first permanent colony. The experience and industrial basis provided by this colony would pave the way towards extensive tunnelling of the Moon using methods we cannot yet dream about. When it is thoroughly developed in this way, the Moon will provide an alternative home for mankind that is as large, varied and beautiful as our own Earth.

NEWS FROM THE CAPE

By Gordon L. Harris

SHUTTLE SCHEDULES

Budget constraints and delays caused by the need to increase Shuttle's payload capacity prompted NASA to drop 14 flights from the 1982-85 schedule, some of which will be conducted later.

Shuttle manifests published in late May listed the following launch schedules: at Kennedy Space Center - two in 1982, seven in 1983, nine in 1984, 13 in 1985, 18 in 1986 and four in the early months of 1987. A West Coast schedule for polar orbits flown from Vandenberg Air Force Base listed a first flight and landing in 1984, three in 1985, five in 1986 and one in January, 1987. Virtually all of the latter are military.

While NASA hopes to conduct the Shuttle's first operational mission in September 1982, the odds suggest a later date. NASA plans a third test flight in February 1982 but if four more months must elapse before the fourth and final teast, only 60 days would remain to install cargo and dispatch *Columbia* on its first operational mission. No-one believes that will happen, hence the likely time frame for operational use will be November-December 1982.

ASTRONAUTS MARRY

Two candidate astronauts selected in the 1978 Shuttle group, Robert Gibson and Margaret Rhea Seddon, married on 30 May. They are not the first married Shuttlenauts because Anna Fisher and her husband William Fisher were selected in 1978 and 1980, respectively.

Soviet cosmonauts Nikalayev (Vostok 3) and Tereshkova (Vostok 6) were married in November 1963.

PIONEER 6

Having completed 15 years in space, Pioneer 6 continues to return data from solar orbit. Launched in December 1965 the 64 kg craft was intended to operate for six months. By its 15th anniversary, Pioneer had circled the Sun 17½ times and radioed measurements 24 hours a day (some four billion data bits). It has measured the Sun's corona, solar storms and solar magnetic field.

Pioneer's instruments include a magnetometer, two solar wind instruments to measure charged particles emanating from the Sun, a radio instrument that measures large segments of the solar wind between Earth and spacecraft, and two cosmic ray instruments to measure very high energy particles coming from the Sun or the galaxy. A seventh celestial mechanics experiment has used Pioneer itself to measure Sun-Earth distance, planetary orbits and relativity data. When the spacecraft travelled behind the Sun, relative to Earth, studies of the radio signal passing through the solar corona added to knowledge of the latter, constituting an eighth experiment.

NEW FINANCIAL SYSTEM

When the Shuttle is in full swing NASA will be using a new accounting system at the Cape to keep track of finances. The system will allow managers to follow finances, for personnel and equipment through a central data base which will also allow modifications if the need arises in the future.

COPERNICUS OBSERVATORY

Science operations of OAO-1 have been terminated after 8½ years. Named Copernicus, the craft was instrumental in the discovery of the first suspected black hole. Its telescope, 81cm. in diameter, provided ultraviolet spectra data invisible to ground-based observers. The mission yielded important data on X-ray sources, like Cygnus X-1, stellar temperatures chemical composition. It also studied the atmosphere of Earth, Mars, Jupiter, Saturn, Titan and Ia.

SHUTTLE SERVICING

As *Columbia* continues its four-flight test series, NASA has drastically modified planning for quick turnaround of the operational vehicles. Having once expected to service Shuttles in only 10 days between missions, the agency now talks of one to two months and says that pace cannot be achieved until 1985 or later. Six flights per Shuttle when four become available would limit NASA to 24 missions per year. And since one of the four will remain at the West Coast military base, in all likelihood, the maximum will drop to 18. On the other hand, if launch crews can halve the servicing period the rate will double to 36 per year.

IUS ON ITS WAY

The Pathfinder vehicle for the Air Force's Inertial Upper Stage arrived at Cape Canaveral during 21 July. The Inertial Upper Stage (IUS) will serve as an unmanned upper stage for both the Air Force's Titan-34D and the Shuttle. The first launch is expected in Spring 1982 with the Titan 34D.

The Pathfinder IUS is, in effect, the stand-in for the first IUS flight vehicle. It is identical to a flight-ready upper stage except that its solid rocket motors and ordnance devices are loaded with inert material. Its role is to proceed through complete launch checkout to the point of liftoff, in order to verify processing procedures, facilities and the mechanical and electrical interfaces between the IUS, launch vehicle and support equipment. It is the same size and weight as the IUS and contains all the flight electronics necessary to prove that the IUS is ready for flight.

The Pathfinder's role involves a number of firsts for the system, including:

1. First electromagnetic interference testing of the IUS system. The Pathfinder is exposed to electromagnetic fields of the type it is expected to face on the launch pad atop the Titan, proving the performance of its components under these conditions.
2. First shipment of the IUS. The Pathfinder is packaged and handled the same way as flight vehicles, providing a checkout of the systemin an operational environment.
3. First activation and checkout of the Boeing and Air Force

IUS facilities at the Air Force's Eastern Launch Site at Canaveral.

4. First mating and fit checks between the IUS and the Titan.

It was transported to the Cape Canaveral Air Force Station by truck in four segments (large solid-rocket motor, interstage, smaller solid-rocket motor and equipment support section) Before being taken to the Solid Motor Assembly Building and assembled. It then went to the Air Force's Launch Complex 40 and placed atop the Titan.

The Pathfinder is one of many reasons the IUS is expected to provide an extremely reliable ride for its scientific and other payloads - it is designed to attain at least 96 percent reliability. Currently, this reliability is predicted at better than 98 percent.

The importance of this reliability is underscored by the IUS's role - it is to carry payloads to orbits that the Shuttle and Titan cannot reach. Boeing is developing and will deliver a similar pathfinder IUS vehicle for the Shuttle in 1982 and this vehicle will also be used for full-dress rehersals.

FLTSATCOM 5

The fifth satellite in the Fltsatcom series was launched by Atlas Centaur 59 on 6 August to provide the US military with communications over the Pacific hemisphere.

Weighing 4136 lb at launch, the satellite was down to about 2200 lb by the time it reached geostationary orbit, from where it would begin its journey to 73°W. Fltsatcom provides 24 channels in the 240-400 MHz band, with the intention of providing a service for the next 5 years. Fltsatcom began operation in February 1978.

VENUS PROBE

The form of the American VOIR (Venus Orbiting Imaging Radar) mission is still uncertain because both the launch date and the launch vehicle are still undecided. When the IUS was dropped from Shuttle planetary missions NASA decided to adopt a modified version of the Centaur cryogenic upper stage. But it still has to be produced and VOIR is being designed by the Jet Propulsion Laboratory with the possibility of a different upper stage in mind.

VOIR could be launched in November 1987 (Type II trajecory) or April 1988 (Type I) for Venus arrival in July/August 1988, to begin its mission of mapping Venus at high resolution (some of it down to 100m).

In order to save carrying a large retromotor, VOIR will use the method of 'aerobraking' for the first time on a planetary mission. It will first enter a highly-elliptical orbit with its periapsis dropping into the atmosphere, with the result that - over the following 30-60 days - the orbit will become almost circularised. An engine burn will raise periapsis to prevent orbital decay and establish a path 250km high. The mission will nominally end some 4-5 months later.

PERCHERON ROCKET

The second attempt to develop a space rocket competitive with NASA and Europe's new Ariane vehicle comes to grips with reality next Spring on Matagorda island off the Texas coast.

Financed by Space Services, Inc., of Houston, Texas and built by GCH, Inc., of Sunnyvale, Calif., a prototype liquid-fuelled engine to propel the new vehicle will undergo static firing on the island.

The first such attempt originated in West Germany where OTRAG built prototype rockets for test launches in Zaire. Zaire's government stopped the tests after three flights and OTRAG is now working in Libya.

A former real estate developer, David Hannah Jr, heads the Texas firm. He said his company contracted with GCH to build a rocket and provide launch site and other technical services at a cost of $2,000,000 initially and $20,000,000 overall. According to Hannah, the "Percheron" rocket will be able to place satellites in orbit for $5,000,000 or from two to six times less than fees charges by NASA or by ESA for Ariane. Hannah predicted his first attempt to acheive orbit will occur in the Spring of 1983.

GCH began engine tests last July on a 3,000-acre leased site and expected to continue testing over the next six months. The first launch of Percheron, according to GCH spokesman Gary C. Hudson, will aim at a 20 miles flight over the Gulf of Mexico and an altitude of 20-30 miles.

Hannah claimed that he has discussed with the US Air Force the possibility of launching Percheron for polar orbiting satellites from Vandenberg Air Force Base, California.

He said that Percheron will place 5,100 pounds into orbit around the poles and up to 2,000 pounds in geosynchronous orbit above the Equator.

The 50ft tall rocket will be 4ft in diameter and be propelled by an engine developing 60,000 pounds of thrust, assisted by up to six strap-on solid propellant rockets. The main engine is of a design similar to the Apollo Lunar Module and Delta's second stage.

(A static test on 5 August ended with the rocket being destroyed in an explosion. A Lox valve failed and the pressure ruptured the tanks. The company had been aiming for a 12 August launch. - Ed.)

NEW WEATHER SATELLITE

The NOAA 7 environmental satellite was launched into a Sun-synchronous polar orbit by a modified Atlas F on 22 June.

It joins its sister NOAA 6 in a 500 mi-high orbit from where it can view the whole Earth at least twice everyday, to provide high-resolution weather information. Its scanning radiometer looks at the Earth in 5 spectral bands to provide data on:

- High resolution, day and night cloud cover observations on a local and global scale;
- High resolution observations of sea surface temperatures;
- Improved observations of vertical temperatures and water vapour profiles in the troposphere and lower stratosphere on a global basis;
- Observations of vertical temperature profils in the middle and upper stratosphere on a global basis;

In addition, it acts as a collector and relay of data from automatic weather stations and balloons.

NOAA 7 is the fourth of a series of eight Tiros-N metsats based on the Air Force's Block 5D vehicles. The GOES satellites perform the same type of work but from their positions in the geostationery orbit where they can view a complete hemisphere (but with reduced resolution). The remaining four NOAA craft will be launched as they are needed.

ON THE RADIO

Visitors to the Kennedy Space Center can now tune in on their car radios to a special band which gives them news and views around the Cape.

VIKING GOES ON . . . .AND ON . . . .

Five years after it touched down on the rocky, dusty Chryse Planitia on Mars, Viking Lander 1 is still sending information about the red planet more than 200 miles back to Earth.

July 20 marked the fifth anniversary of radio transmissions from the unmanned Viking Lander, a milstone unforseen when the mission was planned.

When Viking 1 and 2 were separately launched in 1975, it was expected the twin craft would not continue data communications with Earth much beyond November 1976, four months after the Lander portion of each craft touched down on Mars.

Viking Lander 2, having made its landing on 3 September 1976, ceased radio transmission in March 1980 because of failure in the craft's computers.

But Viking Lander 1 is still making weekly transmissions of weather data and colour pictures of the Martian landscape and sky. Data and pictures are stored and relayed *via* its recorder and received at the Jet Propulsion Laboratory (JPL) in Pasadena, California.

Its primary mission long since completed, Viking lander 1's continuing radio transmissions are helping to extend our knowledge about the surfaces of Mars and its weather patterns and atmospheric conditions, including temperature, pressure and atmospheric dust content.

The radio beacon is also being used to plot Mars' rotation and orbit with greater accuracy than ever before.

One of the most vital pieces of equipment aboard is the recorder, relaying about 2 million bits of data in each weekly transmission.

Weighing less than 20 pounds and only as large as a shoebox (12 × 9 × 6 inches), the digital, reel-to-reel recorder was specially designed to withstand high-temperature sterilisation and the wide differences in Martian temperature, which ranges from -190°F at night to +80° during the day.

To function under such conditions, the recorder was built with graphite-like lubricants that resist boiling, and with a nickel and cobalt coated phosphor-bronze metal tape.

A single motor turns both recorder reels in order to minimise the drain on the Lander's electrical generating capacity.

The recorder is used for several reasons: it saves data that cannot be immediately radioed to Earth when Mars' rotation causes the planet to block the Lander's signal path; it transmits data at a slower rate than they were recorded, providing clearer reception; and it conserves the craft's electrical power.

CANADA AND THE SHUTTLE

Several months of negotiation have resulted in a dual programme arrangement between NASA and a new National Research Council organisation, the Canada Centre for Space Science (CCSS), writes Gerald Borrowman. Dr. Ian McDiarmid, Director of the Centre, stresses the impact it will have on science and industry in Canada. "Although it will focus primarily on space science," he says, "the spinoff to industry is obvious."

The programme will place new demands on Canadian industrial capability. When the Space Shuttle was conceived it was assumed that the payloads would have less stringent design requirements than rocket-launched packages. But, as the Shuttle design evolved, equipment requirements are back up to the more stringent standards. Most of this upgrading is due to the crew safety considerations and the new programme will give Canadian industry an early opportunity to gain experience in Shuttle technology.

Canada's space programme will concentrate initially on investigating the processes responsible for transfering energy from the Sun to the Earth's immediate environment and later may expand to include space astronomy. These studies will be accomplished by Canadian designed and built instruments carried into orbit by the Shuttle.

CCSS will administer a well-defined space science programme over the next six years. When NASA orbits its Spacelab in 1985, the facility will contain three major instruments from Canada.

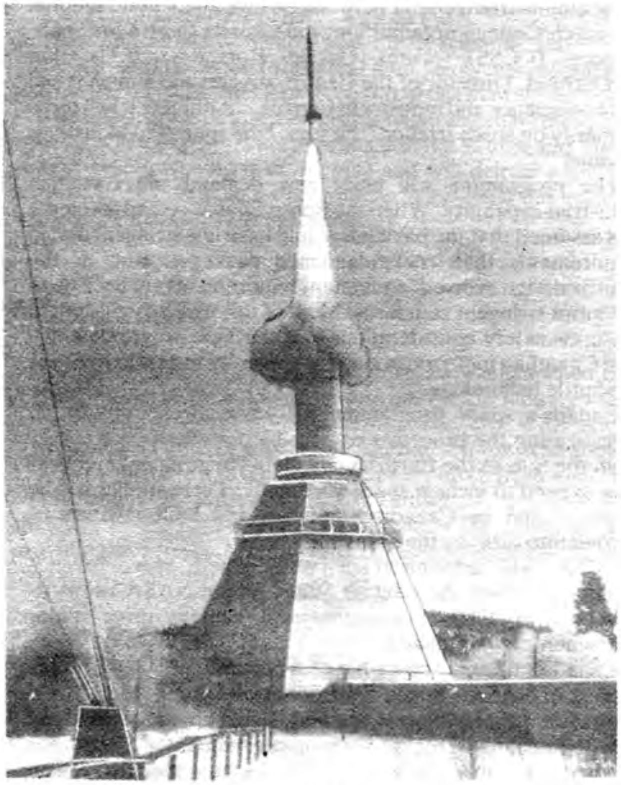
Canada's future in space has thus become entwined with the success of NASA's Space Transportation System. McDiarmid commented that "the concept and design appear sound, and with the decline of rocket-borne experiments, the Shuttle has become 'the only game in town'. Just because there have been failures to meet deadlines it doesn't mean the ultimate success of the Shuttle is threatened, nor the space programmes of our two countries."

The effort which went into the design and testing of the Viking Landers' tape recorders has continued to pay off. Lander 1 is still operating on the Martian surface after more than 5 years.
Lockheed

MORE SKYLARK SUCCESSES

Fifty-two different experiments to investigate the properties and behaviour of materials in the weightless environment of space were launched aboard two Skylark sounding roackets on 1 June.

Launched from Esrange at Kiruna, Sweden, in a co-operative German/Swedish campaign, Texus 3B (Skylark 7)



with a payload of 374 kg reached an apogee of about 252 km and Texus 4 with a payload weight of 364 kg climbed to an apogee of about 256 km to provide 6 minutes of micro-gravity experiment time. The rockets were the latest to be flown in Germany's continuing Texus programme which is proving the suitability of experiments for flight in Spacelab.

The on-board equipment from numerous establishments throughout Germany and Sweden concerned metallurgical, crystal growth and fluid dynamics experiments including, for example, the crystal growth of germanium and eutectic alloys, observation of Marangoni convection in floating zones and capillarity phenomena.

STAFFORD ON SPACE

Speaking on the eve of the maiden launch of *Columbia*, former astronaut Thomas P. Stafford assessed the accomplishments of U.S. Technology in the realm of aerospace engineering, writes Gerald L. Borrowman.

"I think it is very significant how far we've progressed in technology. Sure there's been a lot of delays on the Space Shuttle. But when we had the Flight Readiness Review last week it was the consensus of opinion that the first flight of the Space Shuttle is as clear a vehicle as we had for the first Gemini flight and for the first Apollo flight. I remember how we sweated through each of those problems we had (and) the delays.

"In fact, Walt Williams, the chief engineer of NASA, stated that he thought the condition of it (*Columbia*) is about equal to that of the fourth or fifth flight, of say, either Gemini or Apollo.

"So we're very anxious to see this Space Shuttle, after the initial flight test work, go into operational mode."

Stafford went on to reflect on the role of the Department of Defense in the Shuttle programme.

"John Glenn just recently had an interview on it. His thoughts are exactly the same as mine: that without the Department of Defense behind the Space Shuttle... you would have had just a very meagre programme. Probably just one launch site and only a couple of birds. But I'm optimistic that we will build a total of five to start with. And right now the Vandenberg complex on the west-coast is progressing along. So it can be a very integral working effort between the Air Force and NASA...."

As a member of the Department of Defense transition team for President-elect Ronald W. Reagan, Stafford recommended tnat the Defense Department purchase some long-lead items for expendale boosters. This prudent action was taken in lieu of the great uncertainty of the Space Shuttle reaching operational status.

When asked if he agreed with a suggestion by Senator Harrison Schmitt that a white (NASA) and a blue fleet (Air Force) of Shuttles would evolve, Stafford agreed.

"The charter of the NASA is to develop things. And if you have a lot of your budget tied up in operations you can't develop new ideas and things. This is not the last Space Shuttle we're going to build and NASA needs to keep pushing forward the state of the technology under agreements we have with the Department of Defense that NASA will take the manned vehicles and develop them. But most of the launches from Vandenberg will be Department of Defense launches. And there will be some out of here (Kennedy Space Center). But again, I think you might say that vehicles 103 and 104 will be mostly assigned to the Department of Defense. In fact, a lot of people at NASA have said that they ought to buy those birds and take them."

Stafford went on to describe a possible evolution in the location of the National Command Authority.

"Today, we have our National Command Authorities, a Boeing 747 and a KC-135 that the SAC (Strategic Air Command) commander has. Down the road, I can see this National Command Authority might be delegated to somebody in space. And if you go into equatorial orbit you're really out of the radar coverage of any place in the Soviet Union. A killer-satellite would have a heck of a time getting to you in equatorial orbit, even a low equatorial orbit ..."

The orbital craft housing the National Command Authority would be similar in size to Spacelab with facilities for a maximum crew of four men and be placed in orbit from the payload bay of the Space Shuttle. According to Stafford, "You'd send it off and keep it there for a long period of time. In a way it would be like the way the Russians have a Salyut space station. They leave it for a long period of time and go up and come back. We'd do the same thing."

When asked about the possibility of superpower conflict in orbit Stafford began with a recollection that was fourteen years old.

"....we have a Space Treaty. I remember the day that it was signed. It was January 27, 1967. That was the day of the tragic fire on the Cape and I was in a sister spacecraft running the same test out in Downey, California with John Young and Gene Cernan. That was when Lyndon Johnson signed it in the White House. And what it does is prohibit weapons of mass destruction from outer space and also outlines cooperation for recovery of astronauts...."

Stafford then went on to describe his own role in the anti-satellite programme while serving in the Pentagon.

"We came up, during my time there, with a configuration that would use an F-15 with a SRAM booster with a minature

homing vehicle on the head of it that goes up in just a ballistic trajectory, not into orbit. Whereas, the Soviets use theirs in a concentric orbit with a rendezvous scheme somewhat like most of our Gemini and Apollo rendezvous ... But again, we hope to have an anti-satellite treaty that will work. But so far, it hasn't worked yet."

PIONEER 10

Pioneer 10, now a little over halfway between the orbits of Uranus and Neptune, has found that the Sun's atmosphere and magnetic envelope "extend an enormous distance -- far beyond the point predicted by many scientists," according to James Van Allen, Pioneer investigator.

This discovery means that "if you were living on any other planet, you would find a solar environment surrounding it like that surrounding the Earth. This would include: a constant solar wind, buffeting by solar magnetic storms, and, in many cases, radiation belts," said Van Allen.

Pioneer 10 data can be used to forecast that Voyager 2 will find such "solar" conditions during its encounter with the planet Uranus in 1986, he added. The findings also predict similar solar environment conditions for Neptune.

Information from Pioneer 10 proves the Sun's influence extends to at least 25 AU and probably well beyond. The scientists found no clear evidence of a close approach as yet to the heliopause (the border between the Sun's atmosphere and interstellar space, the medium between the stars).

Some scientists had predicted that the heliopause would be found as close to the Sun as 5 AU.

FREE-FLYING SPACE PLATFORM

One destination for the Space Shuttle during the mid-to-late 1980's may be a free-flying platform permanently stationed in orbit around the Earth, writes Neville Kidger.

McDonnell Douglas engineers say that the platform, orbiting at an altitude of about 225 miles (425 km) would combine a solar power system (current studies of power supply indicate 10 to 25 kilowatts will be required) with extensions or arms to which Shuttle-delivered payloads would be attatched. The concept would allow a single platform to handle multiple payloads, each using the central power system to conduct independent operations.

Features of the platform are:

- Centralisation of resources, such as electrical power, thermal control, stabilisation and communications,
- continuing availability as a rental facility for long - and short-term users,
- a single orbital "address" where the Shuttle will deliver a number of payloads at once.

Such a concept would allow payloads to remain in orbit for periods longer than the Shuttle flight which delivered them. While in orbit, the payloads could be modified, repaired,

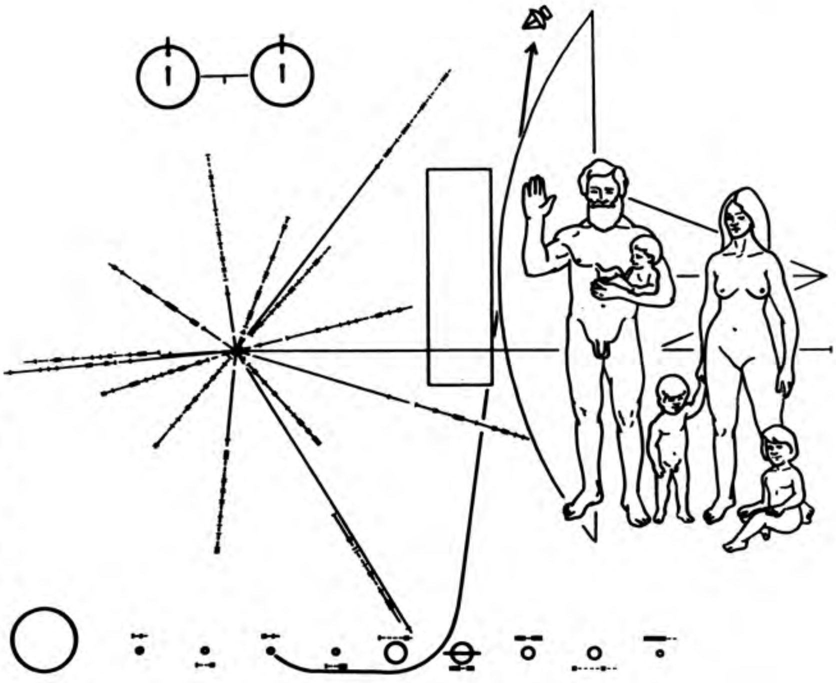
PLUTO'S ORBIT

Since Pluto orbits the Sun at great distances (about 40 times further out than Earth), we have observed it over only about a quarter of a complete orbit since discovery in 1930 by Clyde Tombaugh. Photographs of it go back to 1914 (the images lay there unrecognised for years!) and observations from then up to 1965 were used to compute its orbit.

A new orbit has been calculated by astronomers at the US Naval Observatory using 14 years' more observations since 1965:

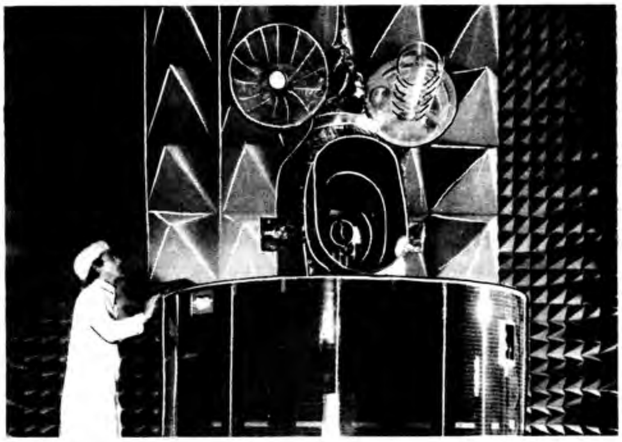
Period: 250.3 years (1972 value: 247.7 years)
Semi-major axis: 39.718 AU (1972: 39.44 AU).

Pluto is presently inside the orbit of Neptune and will remain so until 1999, reaching perihelion in 1989.



A reproduction of the Pioneer 10 plaque? Not quite - take another look. Pioneer, the Jupiter fly-by probe of 1973 reached a distance of 25 AU (2,324,000 miles) from the Sun on 26 July (taking radio signals 3½ hours to reach Earth!). By now, some space wit has decided, the human couple should have acquired a family of three, with the man sporting a beard!

TRW



On 10 August the Japanese launched their GMS-2 weather satellite towards a geostationary orbit above the western Pacific at 140° East Longitude. Very similar to the GOES metsats (see p. 218 of the August-September *Spaceflight),* GMS will return visible and IR pictures of the Earth every 30 minutes, day and night, as Japan's contribution to the extensive world meteorology programme underway at the moment.

The satellite weighs 644 lb once on station, well within the 722 lb geostationary capability of the NII launcher which was used operationally for the first time.

Hughes

replenished by subsequent Shuttle missions, or even returned to Earth periodically. This would allow the Shuttle to handle more payloads than would be possible if each payload had to be serviced separately.

According to McDonnell Douglas Corporation's Manager for Advanced Space Payloads, Fritz Range, "the long duration, multi-payload, free-flight platform not only will be beneficial to many payloads, but will also reduce future demands on mission support elements such as data-relay satellites and the heavily scheduled Orbiter. Using permanent platforms in space for experimental or observational payloads could also enhance the Spacelab experiments now planned for the Shuttle cargo bay. Spacelab's cargo pallets could be removed from the Shuttle and attatched to the platform's arms for longer periods of operation."

VENUS CONFERENCE

Some 500 scientists are expected to attend a Conference in California beginning on 16 November to pool their information about the planet Venus. Results from the Mariner, Pioneer-Venus and Venera probes will be discussed and a book based on the presentations will eventually be published.

LAST OF THE FOURTEEN

With the departure of Al Bean from NASA in June 1981 a significant milestone has passed in the NASA astronaut corps, writes Dave Shayler. He was the last of the third group to leave the space programme, a group which has achieved remarkable records in the 18 years of their existence.

Fourteen pilots were selected in October 1963 and reported for training at Houston 3 February 1964. They were : Aldrin (Gemini 12, 1966 & Apollo 11, 1969) resigned 1971; Anders (Apollo 8, 1968) resigned 1969; Bassett, killed in 1966; Bean, (Apollo 12, 1969 & Skylab 3, 1973) resigned 1981; Cernan (Gemini 9, 1966; Apollo 10, 1969 & Apollo 17, 1972) resigned 1976; Chaffee, killed 1967; Collins (Gemini 10, 1966 & Apollo 11, 1969) resigned 1969; Cunningham, (Apollo 7, 1968) resigned 1971; Eisele (Apollo 7, 1968) resigned 1970; Freeman, killed in 1964; Gordon (Gemini 11 1966 & Apollo 12, 1969) resigned 1972; Schweickart (Apollo 9, 1969) resigned 1979; Scott (Gemini 8 1966, Apollo 9, 1969 & Apollo 15, 1971) resigned 1977; and Williams, killed 1967.

Four were killed before making their first space flights but the remaining ten completed a total of 18 separate flights between 1966 and 1973. Six (Aldrin, Bean, Cernan, Collins, Gordon, Schweickart, and Scott) accumulated some 16h 34m in EVA activittes in free space, while four (Aldrin, Bean, Cernan, and Scott) also logged a total of 51h 46m in EVA on the Lunar surface. Three of the Fourteen (Bean, Cernan and Scott) served as Mission Commanders on each of their final missions.

With only one astronaut from each of the two earlier groups (Slayton from Group 1 and Young from Group 2) still remaining with NASA, the 73 astronauts originally selected between 1959 and 1969 for the initial manned programmes are currently down to 26 astronauts with only 25 on flight status (Slayton is on a full time desk job, unavailable for future flights).

US NAVIGATION SATELLITES

The US military are expected to spend up to $1,500 million on navigation satellite systems in the next 5 years. Most of the money will go to the Navstar satellites which are intended to be fully implemented by FY1985.

SPACE TELESCOPE

The Scientific Programme Committee of ESA have decided to select the European Southern Observatory (ESO) as the Institute that will host the European Coordinating Facility (ECF) for the Space Telescope (ST). The ECF will work closely with the United States Space Telescope Science Institute which is being established by NASA and which will be located in the Johns Hopkins Unieristy in Baltimore (Maryland).

The Space Telescope is a 2.4 m optical telescope due for launch by the Shuttle in about 1985. As a free-flying instrument it will be able to probe some six to eight times father than ground-based instruments.

The main task foreseen for the ECF will be to coordinate work throughout Europe on ST data analysis software, to concentrate and distribute information on the ST itself and to make available advanced computer facilities to the European astronomers. The creation of this centre in Europe will play a major role in ensuring that European astronomers will be in the best possible position to obtain the maximum scientific return from the high quality ST data.

A total of about 14 people, half of whom will be ESA staff members, will eventually be active in the European Coordinating Facility which will be open to astronomers from all ESA Member States. The Facility will be located in the Headquarters of the European Southern Observatory in Garching bei Munchen, Germany.

ESO is an intergovernmental organisation for astronomical research with six member states - Belgium, Denmark, France, Germany, Netherlands and Sweden. Two other countries, Italy and Switzerland, are in the process of formally joining the Organisation.

EXOSAT

ESA has asked for observing proposals for Europe's X-ray astronomical satellite, Exosat, due to be launched by Ariane in July next year.

Four X-ray instruments will cover a broad range of energies to provide data on the positions of sources, the form of diffuse emitting areas, and the X-ray spectra and variability of sources.

Meanwhile, the International Ultraviolet Explorer (IUE), launched in 1978, continues to work apace. In June ESA asked for new observing proposals to extend the schedule to April 1982.

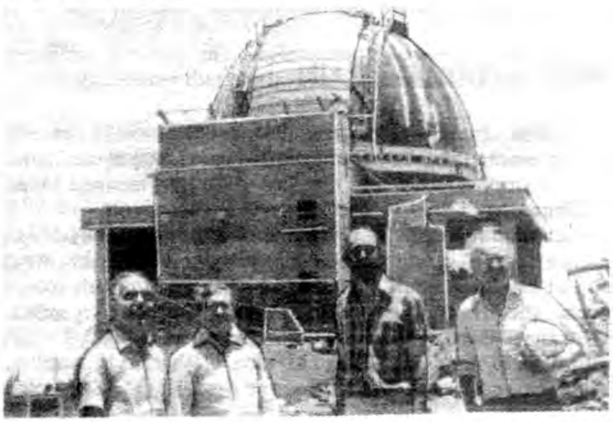
ANGLO-DUTCH COLLABORATION

The UK's Science and Engineering Research Council (SERC) and the Dutch Research Council signed a Protocol on 18 June under which they will collaborate on a new observatory being built on the island of La Palma in the Spanish Canaries.

The Netherlands is to join SERC in building and exploiting four telescopes to be completed by 1896. These will be:

1. A 4.2 m optical telescope of advanced design (the William Herschel Telescope) which will be one of the largest optical telescopes in the world;
2. A 2.5 m optical telescope, which is the refurbished and remounted Isaac Newton telescope from the Royal Greenwich Observatory at Herstmonceux in Sussex;
3. A 1.0 m optical telescope for photometry and other complementary programmes in support of the two larger telescopes;
4. A 15 m radio telescope for observations at wavelengths around 1mm, the region of the electro-magnetic spectrum in which molecular clouds between the stars radiate and give valuable information on star formation.

The mountain top on La Palma has been shown by SERC scientists to be one of the best observing sites in the northern hemisphere. The need of several European nations to have access to such a good site led, in 1979, to an international agreement between Spain, the UK, Sweden and Denmark to create a major new observatory. It will be known as the Roque de Los Muchachos Observatory. Spain is providing the site and infrastructure and the other nations are constructing telescopes. The SERC's Royal Greenwich Observatory leads the British involvement.



The La Palma observatory site. *Left to right:* Prof. F. Sanchez Martinez, Sir Geoffrey Alan, Dr. P. Williams and Prof. F.G. Smith.
Royal Greenwich Observatory

NIMBUS 7 OZONE EXPERIMENT

Encouraging initial results were reported from the first operational test to determine the effectiveness of satellite data for helping airlines to avoid heavy concentrations of ozone.

Ozone, which can be encountered by airliners at high altitudes, has caused shortness of breath as well as eye, nose and throat irritation among some airline passengers.

The two-month experiment began last March and was conducted jointly by NASA, the Federal Aviation Administration (FAA), the National Center for Atmospheric Research (NCAR), and Northwest Airlines.

Information from the Total Ozone Mapping Spectrometer aboard the experimental Nimbus spacecraft was transmitted to NASA scientists at Goddard Space Flight Center who processed the data and relayed it within three hours to Northwest Airlines meteorologists in Minnesota for use in forecasting. Early results show:

1. The Total Ozone Mapping Spectrometer profile of total ozone in the atmosphere accurately represents upper air patterns and can be used to locate or verify meteorological activity, such as trough lines and rapidly moving fronts. The latter are associated with clear air turbulence and improved knowledge of their location over the oceans help pilots to avoid them.

2. Route forecasting of highly concentrated ozone appears feasible because the tests showed that higher amounts of ozone in aircraft were found in areas where Total Ozone Mapping Spectrometer measured high total ozone amounts.

Additionally, five research aircraft flights flew in jet stream regions located by the Total Ozone Mapping Spectrometer to determine winds, temperatures and air composition at as many as 10 different flight levels.

Initial findings from these flights showed that the jet stream pattern coincides with the area of highest total ozone gradient, and low total ozone amounts are found where tropospheric air has been carried along above the tropopause on the anticyclonic side of the subtropical jet stream.

IN THE PAST

20 years ago....
The first Saturn launcher, SA-1, lifts off from Canaveral on 27 October 1961. The 925,000 lb vehicle rose to a height of 84.8 miles in a successful test flight. It was another 7 years before men rode the booster and the last Saturn went aloft in 1975.

15 years ago....
A hectic time for the launch teams at the Cape: on 3 November 1966 the Titan IIIC carrying the Gemini 2/MOL payload was orbited; Lunar Orbiter 2 departed for the Moon; and astronauts Lovell and Aldrin flew aboard Gemini 12 during 12-14 November. The manned programme was in full swing and Apollo was around the corner - what could go wrong?

10 years ago....
On 14 November 1971 Mariner 9 swung into orbit about Mars to become the first artificial satellite of that planet.

5 years ago....
The two Viking landers on Mars are turned off on 7 November for about a month as the planet is hidden by the Sun. Both are reactivated successfully. Lander 1 is still working, sending its weekly reports and pictures.

D.J. SHAYLER

COMSAT NEWS

MARITIME DEVELOPMENTS

In the October issue of *Spaceflight* (p.207) we reported that Inmarsat, the International Maritime Satellite Organisation, had agreed to lease capacity on Comsat General's Marisat 2 (Pacific) satellite to begin a high quality global comsat system for shipping.

Now, in a decision reached at its 8th council meeting in London (24 June - 1 July), it will lease capacity from Marisat 1 (Atlantic Ocean) and Marisat 3 (Indian Ocean) in order to begin the global service on 1 February 1982. If Ariane successfully launches the Marecs A and B satellites they will be used instead later on, together with new Intelsat V craft.

By the time Inmarsat takes over from the Marisat system on 1 February 1982, the number of Earth stations aboard ships in use is expected to be nearly 1,000. Technical arrangements agreed by the Inmarsat and Comsat General will ensure that the transition from Marisat to Inmarsat is accomplished without interruption to service to users and with minimum inconvenience to ship Earth station manufacturers.

Because of the advantages of satellite communications - fast connection and calls free of fading and distortion - the number of ships using the system is expected to increase rapidly over the next few years.

In addition to telephone, telex, facsimile and low-speed data, the Inmarsat Council has agreed on specifications for high-speed data to be available from the outset of the system. The specifications will ensure that ships using Marisat high-speed data services will be able to transfer to the Inmarsat system without interruption. The high-speed data facilities are expected to be particularly valuable to the oil exploration industry.

The Council also approved detailed technical requirements, as well as type approval and commissioning procedures, for Inmarsat "Standard A" ship Earth stations. The technical standard agreed will provide a common guide to countries, users and manufacturers, while the type approval procedures agreed will facilitate the acceptance of equipment internationally. Commissioning procedures have to be completed before a ship Earth station can start operating with the Inmarsat system.

With its standard A approvals, Inmarsat has now completed the task of defining standards for the three components of its system - the space segment, the coast Earth stations and the ship Earth stations. Inmarsat will be involved in ship Earth station type approval procedures from August 1, 1981, but commissioning will continue to be handled by Comsat General until February 1, 1982.

AUSTRALIAN COMSATS

ESA is to help the Overseas Telecommunications Commision Australia in evaluating bids for the Australian Satellite Communications System. This is a follow-up contract to the study of satellite system design and the assistance ESA gave in the preparation of the tender.

INTELSAT V IN SERVICE

The 12,000-telephone call-capacity Intelsat V comsat launched on 23 May has come into service above the Atlantic, linking the Americas with Europe and Africa, among others.

On 14 July the first public traffic travelled between the Earth stations at Etam, W. Virginia and Usingen in W. Germany. This uses the 14/11 GHz narrow beams which connect the areas of heaviest flow but the full 6/4 Ghz service will not be available before the end of the year. The present main satellite above the Atlantic, an Intelsat IVA, will be joined by the V at 335.5 deg. longitude East to begin a gradual switchover. The new craft has almost twice the capacity of its predecessor.

The Global Traffic Meeting held in Washington, D.C. in July and attended by more than 250 delegates from 126 countries, showed how much of a leap there is going to be in comsat traffic over the next few years. The meeting collected information from the delegates on what services their countries would need in the short term. Preliminary analysis suggest that traffic requirements will *almost double* in the three regions (Atlantic, Indian and Pacific Oceans), with the world total rising from 28,500 in 1981 to 54,600 in 1985.

This emphasises the huge market waiting to be exploited. Intelsat themselves will continue with more Intelsat V vehicles, followed by the VA version (15,000 simultaneous telephone calls) and, in 1986, the VI with a capacity of 40,000 calls.

COMSAT STUDIES

ESA have engaged Logica of the UK to undertake a study which will help to provide a basis for designing future European comsats. The project, known as the Geostationary Orbit Capacity Study, will include a model of that orbit - i.e. how many comsats it can cope with before it becomes saturated - and predictions on the growth of communications traffic over the next 20 years.

British Telecom have also asked them to investigate what UK commercial users will want from European comsats by 1983, when ECS and Telecom 1 will provide data, voice and video conference links.

A study by Intelsat will look at the expected demands for domestic comsat coverage (i.e. linking regions within one country) in the 1980's. If the demand is sufficient - and it probably will be - further studies will determine what type of satellite service will be required.

COMSAT AWARD

Despite the extensive boycott of the Olympic Games in Moscow during the summer of 1980, Intelsat handled 432 Games broadcasts to a total of 37 countries.

As a recognition of the work, the USSR presented Intelsat with a certificate and medallion on 9 July at the organisation's headquarters in Washington, D.C.

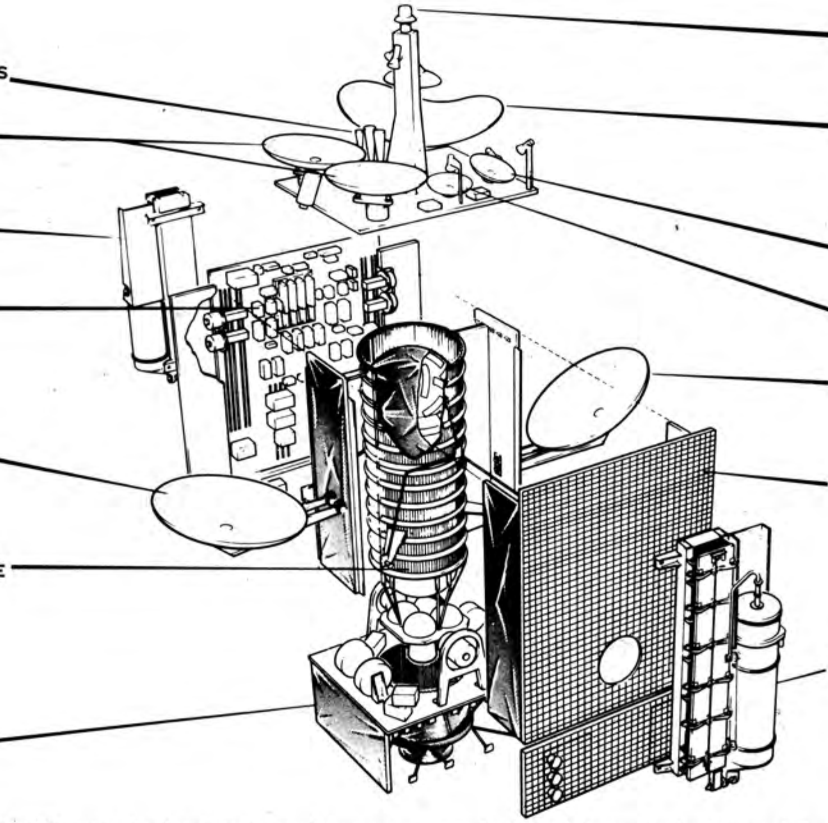
While not a member of Intelsat, the USSR does operate with the Intelsat satellites over the Atlantic and Indian Oceans through its Earth stations at Dubna, L'vov and Moscow.

THAT WEDDING AGAIN

The use of comsats for transmitting TV coverage between nations reaches its peak during world events such as the World Cup, Olympic Games and - in days gone by - manned Moon landings.

The wedding on 29 July of Prince Charles and Lady Diana Spencer was such an event. Three weeks before the event comsat bookings could be seen to be heading towards record levels for transmissions to, among others, Argentina, Australia, Barbados, Bermuda, Brazil, Canada, Dubai, Gibraltar, Hong Kong, Japan, Mexico, Netherlands, Antilles, New Zealand, South Africa, South Korea, United States and Venezuela.

The previous record (for Intelsat) was for 30 March 1981, the day of President Reagan's shooting, when 111 transmissions were made.



L-Sat will be launched in 1985 as a technology-proving multipurpose comsat, dealing with inter-city, business and direct-TV communications.

British Aerospace

NEW SATELLITE TV SERVICE

Intelsat has established a new service for full-time international television relays.

The new service, which allows full-time 24-hour a day transmission over a dedicated network, will promote much more extensive relay of television programmes among countries either within a region or among any international community of countries interested in sharing television programming.

The current occasional-use TV service on the Intelsat system is provided on a per-minute basis and has grown rapidly over the past 16 years. A total of 572, 400 minutes of transmissions were made during 1980.

It is anticipated that the availability of the new full-time televiion channels will open up a broad new area on Intelsat service growth, based upon at least two factors:

- The growth of world-wide production of video programming that has occurred within the last few years;
- The convenience of 24-hour a day satellite transmission operating to an international network of countries.

The new service will cover channels of between 18 and 36 MHz and will be available on either global, hemispheric or spot beam transponders.

INTELSAT VI

By the time of the deadline late last July, Intelsat had received two proposals - from Ford and Hughes - for its next generation of satellites (see *Spaceflight,* August-September. p. 206). Contracts will not be let until next March but the new craft will probably handle about 40,000 telephone circuits plus TV and be available in 1986 for launching by either Ariane 4 or the Shuttle.

NEW COMSAT VICE-PRESIDENT

Joel Alper was appointed in July as Vice-President for Communications Services of the Comsat organisation. He will be Comsat's representative on the board of Intelsat.

NEW SATELLITE TERMINALS

Marconi and Mitsubishi are building two satellite ground stations for installation at Stanley Point in Hong Kong. They should be operational in November 1982 and January 1983, respectively, joining two other stations already in use to handle a large part of the Far East's comsat traffic.

Mitsubishi will provide 29.6m dishes capable of withstanding 210 mph winds - they will remain locked onto their targets even when they are being buffeted by 118 mph winds - while Marconi will produce the electronic equipment.

Projected Marconi Earth station work includes:

Madley I	1981	Expansion of Standard A
Goonhilly V	1981	Inmarsat coast station
Nepal		Turnkey Standard B
Goonhilly IV	1982	Conversion to Standard C
Goonhilly II	1982	Second polarization Standard A
Hong Kong III	1982	Standard A
Hong Kong IR	1983	Standard A
Madley II	1983	Second polarization

DELTA-SCOUT UPDATE

By Andrew Wilson

Introduction

The introduction of the Space Shuttle should have led to the phasing out of NASA's stable of expendable launch vehicles by the middle of this decade. But the delays in the Shuttle programme and the realisation that more payloads than launch places will exist have convinced planners that the launchers of the 1960's and 1970's will have to remain available for some years to come. For the same reason, Europe's Ariane launcher is likely to be a commercial success.

The Delta and Scout - for medium and smaller class payloads, respectively - are two vehicles which will remain operational.

Descriptions of both launchers have already been given in *Spaceflight* [1,2] and it is now possible to look at their use in the Shuttle era.

Delta

The description of Delta in [1] gave a listing of launchers up to number 146 in November 1978. Table 1 extends that list to this year and it can be seen that two new Delta variants have been introduced, the 3910 and 3910/PAM.

The 4-digit number is a very useful system for describing a particular Delta's configuration:

digit 1 — describes the 1st stage, a 3 indicating an Extended Long Tank Thor with RS-27 engine and Castor IV strap-on boosters;

digit 2 — is the number of strap-ons carried (3 to 9);

digit 3 — is the 2nd stage, 0 indicates the AJ10-118F engine, 1 the TR-201 (developed from the Lunar Module Descent Engine), and 2 the AJ10-118K engine.

digit 4 — describes the 3rd stage: 0 indicates no stage, 3 the TE-M-364-3 and 4 the TE-M-364-4.

So the 3910 is the 3914 introduced in December 1975 but without the 3rd stage. The 3910/PAM uses McDonnell-Douglas' own Payload Assist Module as 3rd stage, an addition which will also be used on the Shuttle as the Spinning Solid Upper Stage-Delta class (SSUS-D).

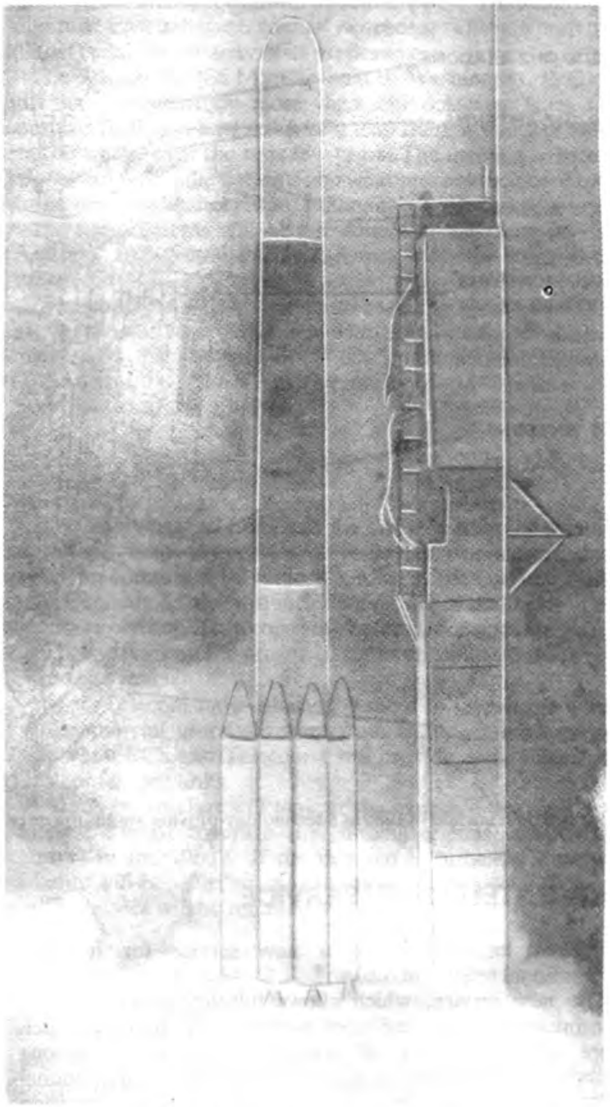
Even though only a small number of 3900 variants have been used, there is a wide range available for payload planners:

3910	2-stage launcher
3913	3910 + TE-M-364-3 3rd stage
3914	3910 + TE-M-364-4 3rd stage
3910/PAM	3910 + PAM 3rd stage

3920	2-stage launcher
3923	3920 + TE-M-364-3 3rd stage
3924	3920 + TE-M-364-4 3rd stage
3920/PAM	3920 + 3rd stage

Table 1. Delta Launches subsequent to 146 [1].

No.	Payload	Date	Type
147	TelesatD	16 Dec 78	3914
148	Scatha	30 Jan 79	2914
149	Westar C	~~8 Oct 79~~	2914
150	RCA-C	7 Dec 79	3914
151	SMM	14 Feb 80	3910
152	GOES 4	9 Sept 80	3914
153	SBS 1	15 Nov 80	3910/PAM
154	GOES 5	22 May 81	3914
156	Dynamic Explorer	31 Jly 81	3913



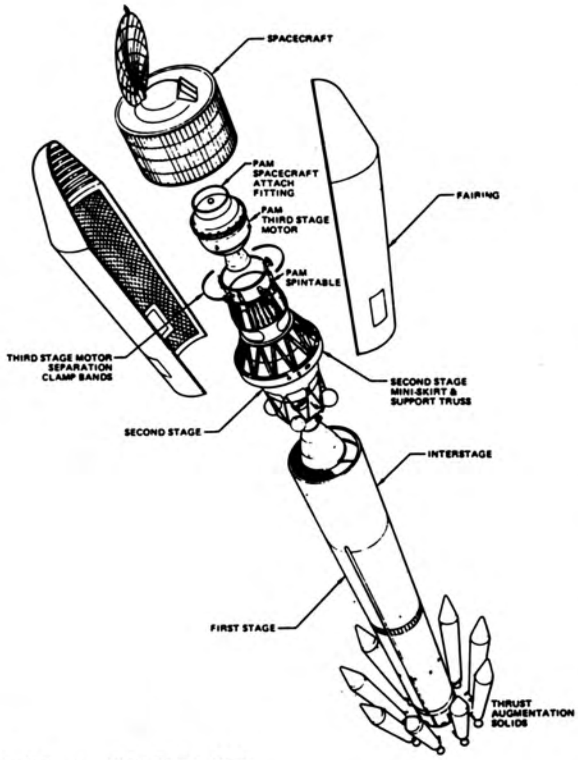
Launcn ot the GOES 4 geostationary weather satellite in May 1981 by a Delta 3914.

Use of the PAM

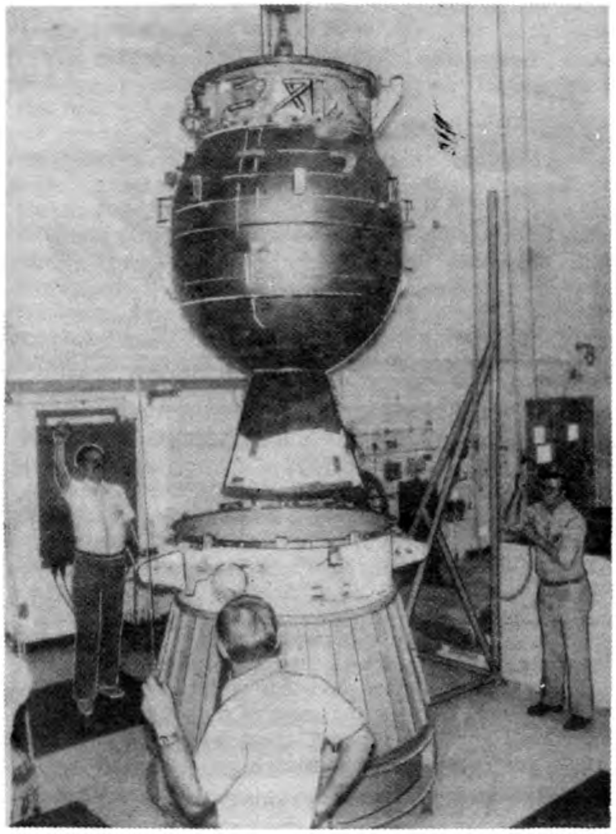
Before the arrival of the new PAM 3rd stage, the previous orbital capability of Delta was about 2000 lb. SBS-1, in contrast, weighed 2411 lb at launch and a future uprating of PAM could increase its capability even further.

McDonnell Douglas originally proposed PAM for the Tracking and Data Relay Satellite. Their bid was unsuccessful but, as the major contractor for Delta, they recognised its potential in the coming years of heavier comsats and decided to press on with it as a private venture, offering it to users on a commercial basis.

Basically, it is a 48 in. diameter motor with a near-spherical titanium casing carrying 4400 lb of propellant (which can be reduced for less demanding missions) to provide a total impulse of 1,268,500 lbf-s and a burn period of 85s. It carries its own electronic control assembly with timer and batteries. In a



Main features of the Delta 3920.



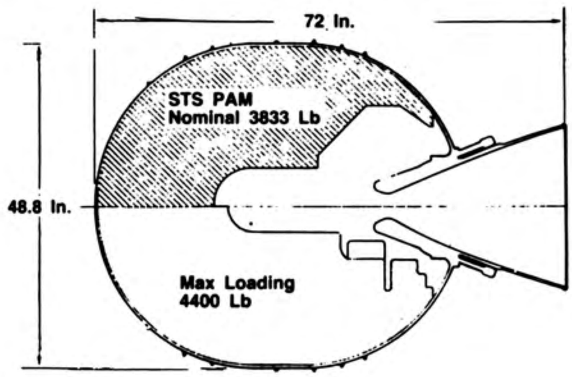
PAM being lowered onto the spin table above the Delta second stage. *MDAC*

typical mission to geostationary orbit it is spun up by small rockets on a spin table and then separated from stage 2 by explosive bolts and four springs. About 20 minutes after launch the Thiokol Star 48 motor ignites and burns out at a speed of about 23,000 mph. More explosive bolts and springs separate the satellite which can then use its own apogee kick motor to establish geosynchronous orbit.

A unique feature of PAM is that it will also see service aboard the Shuttle. It is designed so that if a payload shifts from Delta to Shuttle then no switch in upper stage is necessary. In the Orbiter's cargo bay it will be mounted on a support structure (instead of Delta's second stage) which can be returned for reuse. Up to four can be flown in one mission.

With Shuttle, it will be able to take 2750 lb to GEO from a 27° orbit and an increase in propellant capacity by lengthening the case will uprate that to about 3000 lb. PAM-A will deal with payloads in the Atlas Centaur class but it will fly aboard the Shuttle only.

PAM performed with near perfection on its first flight but,

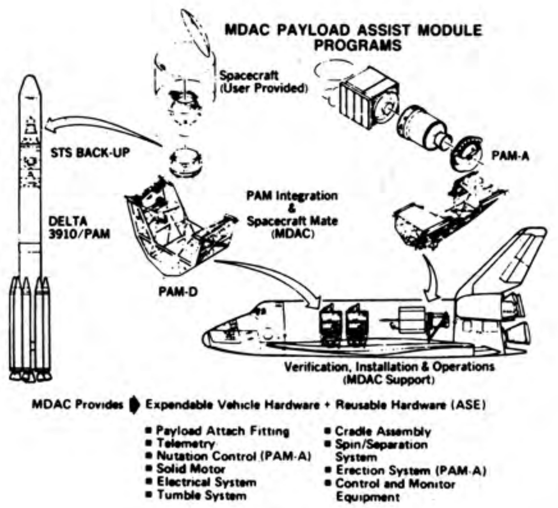


PAM-D configuration (STS refers to Shuttle).

Table 2. Delta payloads to mid-1983.

Payload	Vehicle	Purpose
SBS-B	3910/PAM	comsat
SME	2310	solar observatory
RCA-D	3910/PAM	comsat
RCA-C'	3910/PAM	comsat
1982		
Westar IV	3910/PAM	comsat
Insat 1A	3910/PAM	comsat
IRAS	3910	astronomy sat
Telesat-E*	3910/PAM	comsat
Landsat-D	3920	Earth resources
Telesat-F	3920/PAM	comsat
Westar V	3910/PAM	comsat
RCA-E*	3910/PAM	comsat
GOES-F	3914	metsat
1983		
Palapa B1*	3920/PAM	comsat
RCA/ASTRO	3910/PAM	
RCA-F*	3910/PAM	comsat
Telesat-G*	3910/PAM	comsat
HCI-A	3920/PAM	comsat (Hughes)
Telstar 3A	3920/PAM	comsat

Since this table was compiled, Palapa and Telesat E/F have gone to the Shuttle.



Delta/Shuttle launchers for this decade.

MDAC

before a second could be launched, a PAM under test last December as part of a USAF programme failed. The nozzle failed and McDonnell-Douglas had to correct the faults before any more could be used and some of the Deltas had to be rescheduled. The RCA-D and -C' comsats were shifted back to October and December, respectively.

Future Delta usage

Table 2 gives a launch schedule for Delta as it stood at the beginning of last May (the most recent manifest available to the author). Many of the payloads may move to the Shuttle since Delta is being offered to users as a back-up vehicle in case of Shuttle delays. Those marked with '*' are most likely to be affected and the list extends only to mid-1983 since changes before then will probably render it grossly inaccurate.

Table 3. Scout launches since [2].

Vehicle	Date	Site	Payload
202C	18.02.79	Wallops	SAGE
198C	02.06.79	Wallops	Ariel 6
203C	30.10.79	Vandenberg	Magsat
192C	15.05.81	Vandenberg	Nova 1

Table 4. Projected Scout Launch Schedule

Vehicle	Mission	Launch Schedule
S-308C	NAVY-22 (NOVA-2)	October 1981
S-206C	San Marco DL	1st Qtr. 1982
S-204C	NAVY-21 (Transit)	2nd Qtr. 1982
S-209C	Air Force-15	1st Qtr. 1983
S-211C	Air Force-16	3rd Qtr. 1983
S-207C	San Marco DM	4th Qtr. 1983
S-213C	Air Force-17	4th Qtr. 1983
S-214C	Air Force-18	1st Qtr. 1984
S-215C	Air Force-19	2nd Qtr. 1984
S-199C	NAVY-24 (Transit)	3rd Qtr. 1984
S-212C	NAVY-25 (SOOS-1)	4th Qtr. 1984
S-205C	NAVY-26 (SOOS-2)	1st Qtr. 1985
S-216C	NAVY-27 (SOOS-3)	2nd Qtr. 1985
S-217C	NAVY 28 (SOOS-4)	3rd Qtr. 1985
S-210C		
NAVY-23 (NOVA Back up if required)		

Scout

Smaller payloads are launched by the Scout rocket from either California or the Indian Ocean (Wallops Island in Virginia saw its last Scout in June 1979). At present the intention is to phase Scout out in 1985 by which time it will have been fired into space on well over 110 occasions.

NASA's requirements ended with Magsat and the subsequent payloads are either military (e.g. navigation) or foreign (the Italian San Marcos). Table 4 presents a schedule which, again, may change with time.

Acknowledgements

The writer would like to thank D.W. Grimes, Delta Project Manager, of the Goddard Space Flight Center and the Public Affairs Office at NASA's Langley Research Center.

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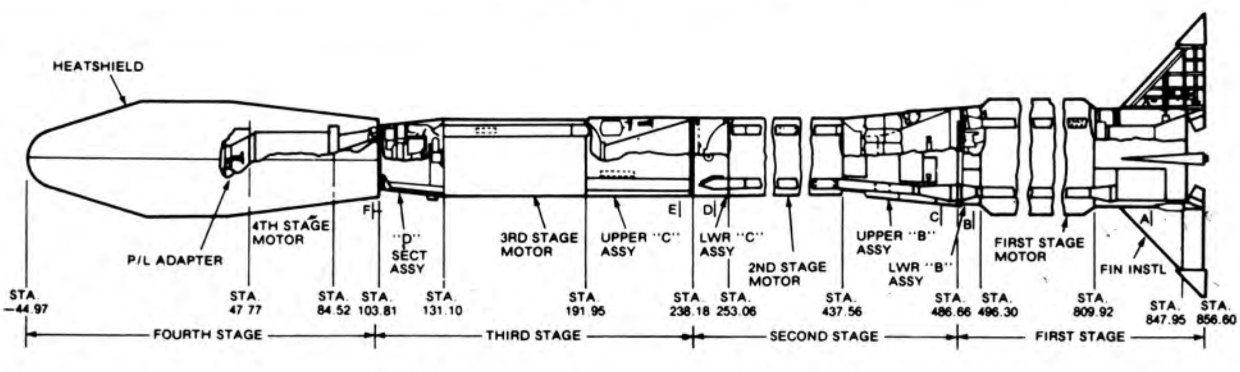
1. A. Wilson, 'Delta Digest', Spaceflight, **21**, 10, pp. 413-419 (1979).
2. A. Wilson, 'Scout NASA's Small Satellite Launcher', **21**, 11, pp. 446-459 (1979).



The Scout has gone through many modifications of its basic four-stage version. This is the G-1 vaiant first used in launch 101 in October 1979. It will probably be the standard vehicle in service at phase-out in 1985.

MARS IN 1995!

By Bob Parkinson

Why not send men to Mars? That is the question posed by this challenging article from B.I.S. Fellow Bob Parkinson. He argues that a manned Mars trip is not only possible using existing technology, but is also more desirable than sending a series of unmanned probes.

The article highlights the main points of such a trip. For interested readers, a detailed analysis appears in this October's issue of *Space Chronicle*.

Introduction

In 1970, at the height of the Apollo programme, NASA unveiled its plans for the next thirty years in space. Not only did it include development of a re-usable Space Shuttle, it also had permanent Space Stations, a nuclear inter-orbital vehicle, bases on the Moon and a manned expedition to Mars before the end of the century. That "before the end of the century" was a conservative estimate at that - the earliest NASA would propose for such a mission was 1983.

Then, in 1972, the nuclear NERVA stage was cancelled and all such plans were abandoned. At the moment even a return of men to the Moon in this century seems only a distant possiblity.

About two years ago I began to wonder whether it had to be so. Viking had raised a host of questions about Mars, but to explore them with robot probes would demand a vast commitment of resources spread over decades. And back in 1952 von Braun had proposed manned missions to our neighbour planet using chemical propulsion with the very modest specific impulse of 2800 m/sec. Rocketdyne and NASA have tested the components for an Advanced Space Engine with a specific impulse in excess of 4660 m/sec, and that could make nuclear propulsion quite unnecessary.

This article is a brief description of the results of that study. It represents a *conservative* estimate for the requirements for a 1995 mission to Mars, using (as far as possible) of-the-shelf hardware. David Hardy helped by painting three marvellous impressions of key moments in the mission.

Available Hardware

You cannot plan a mission for 1995 without making some assumptions about the hardware which may be available by that time.

Chief among the assumptions are possible developments to the Space Shuttle. While launch costs are not an overwhelming factor in planning the mission, it is going to be necessary to launch some large boost stages (about the size of the Saturn IV-B stage) and the diameter of the Mars Landing Module is likely to be considerably bigger than the Shuttle cargo hold. Fortunately, NASA have already been looking at a Heavy Lift version of the Shuttle (*Spaceflight* 1978, p.135) in which the recoverable orbiter would be replaced by a "propulsion capsule" carrying the Main Engines and avionics, and the cargo would be carried externally.

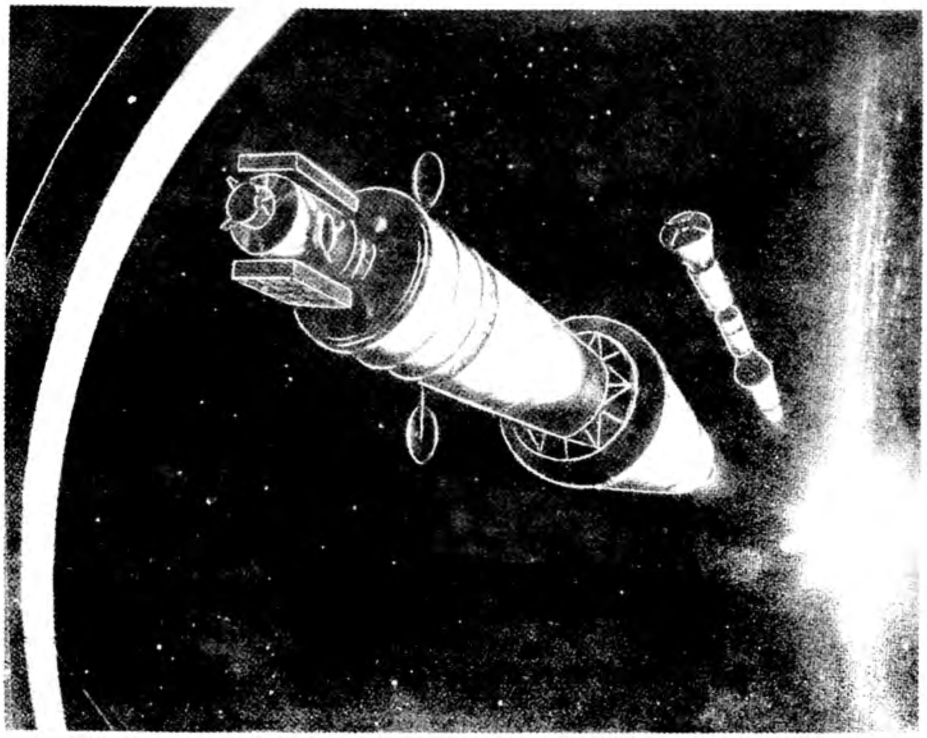
The second assumption concerns the availability of an Orbital Transfer Vehicle. It now looks probably that NASA is going to adapt Centaur for operation with the Shuttle, but if it is to launch some of the larger, heavier payloads proposed for geosynchronous orbit in the late 1980's, Centaur will have to get fatter and heavier. Studies have already been carried out on such a stage, and these have been used to provide propulsion for the mission.

The final assumption concerns the development of free-flying Space Stations. There is considerable pressure growing in the USA now to develop a Space Operations Center as a successor to the Shuttle, but as yet the size and mass of such a Center has not been defined. Instead, I have used the data on Spacelab and the proposals to convert it into a free-flying module with the addition of a large, unfoldable solar arry (*Spaceflight* 1979, p.349) to provide a European dimension to the project.

Mission Outline

In many ways the mission planning must follow the outline indicated by the planning for nuclear missions in the late

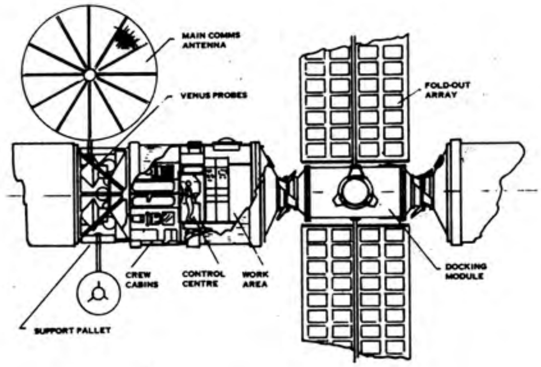
Continued on p.311

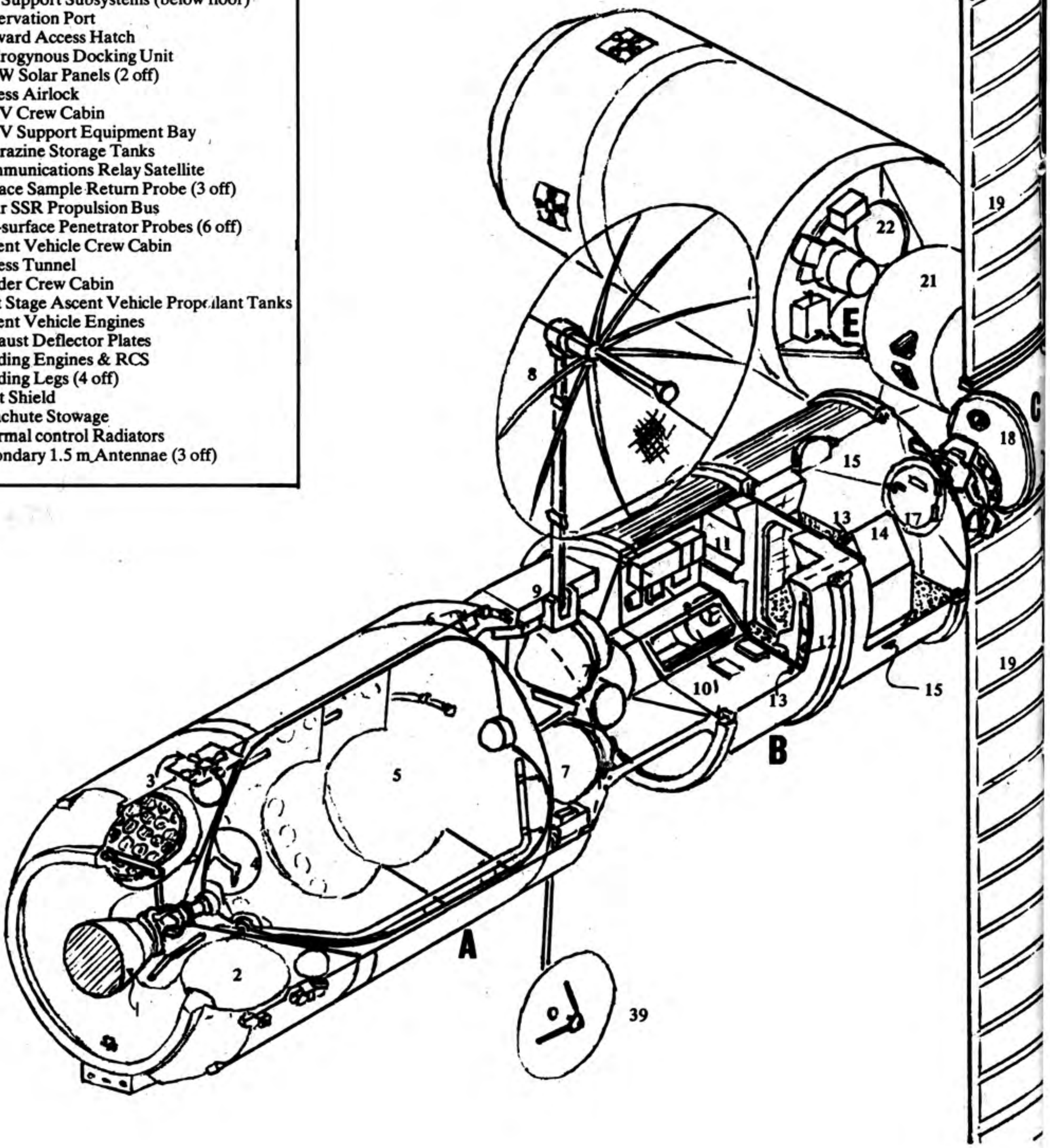


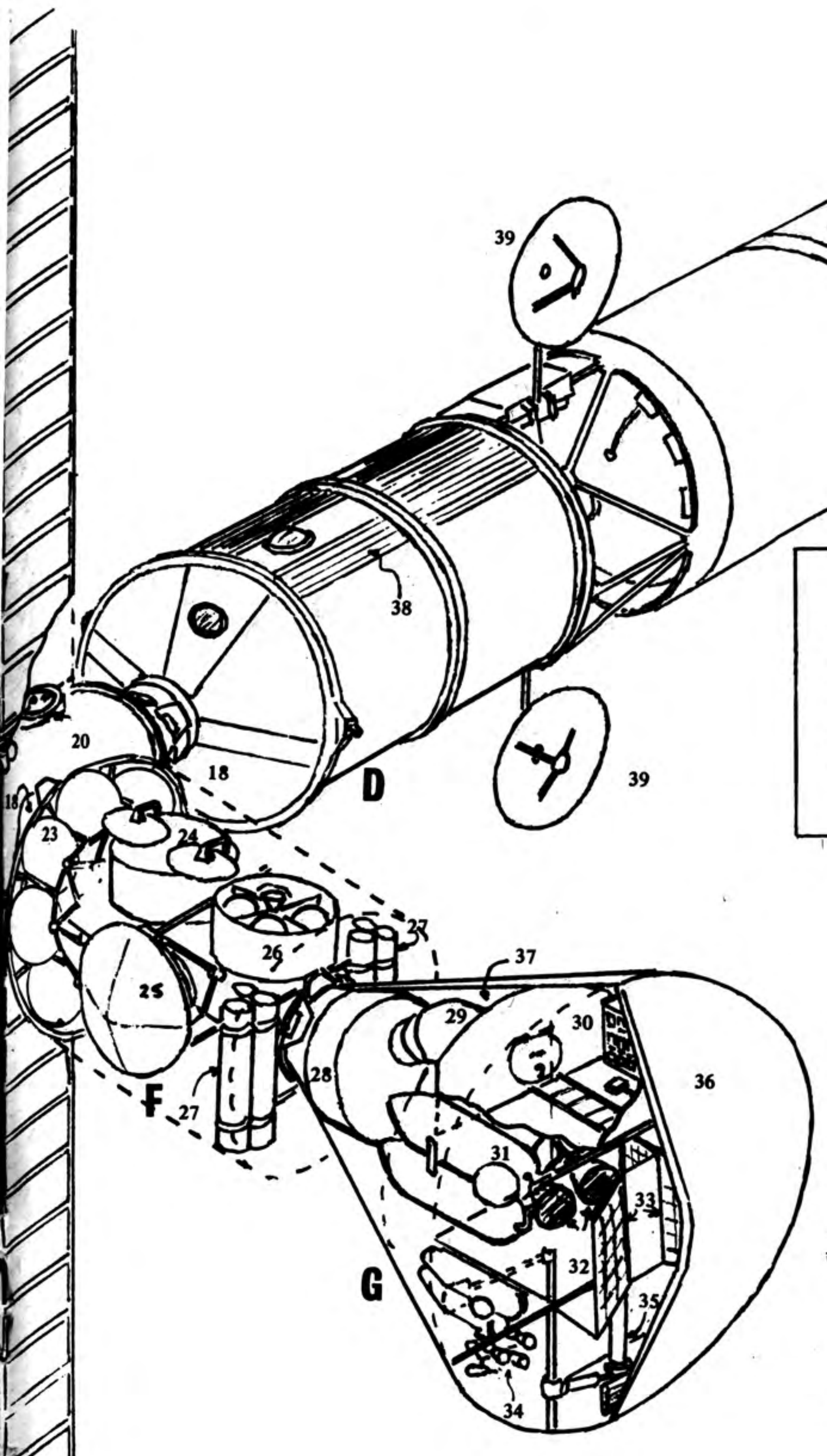
Viewed from a porthole in Orbiter 1, the other two ships come "out of the Sun" as they leave Earth orbit.
Copyright David Hardy

KEY

1. Advanced Space Engine
2. Toroidal Liquid Oxygen Tank
3. RCS Thrusters
4. Helium Pressurization Tank
5. Liquid Hydrogen Tank
6. OTS Control Electronics
7. Venus Probes (2 off)
8. Main 6 m. Communications Antenna
9. Support Equipment Pallet
10. Crew Cabin (3 off)
11. Control Centre
12. Water Storage Tanks
13. Polythene Radiation Protection Bulkheads
14. Electronic Equipment Racks
15. Life Support Subsystems (below floor)
16. Observation Port
17. Forward Access Hatch
18. Androgynous Docking Unit
19. 17 kW Solar Panels (2 off)
20. Access Airlock
21. IOTV Crew Cabin
22. IOTV Support Equipment Bay
23. Hydrazine Storage Tanks
24. Communications Relay Satellite
25. Surface Sample Return Probe (3 off)
26. Polar SSR Propulsion Bus
27. Sub-surface Penetrator Probes (6 off)
28. Ascent Vehicle Crew Cabin
29. Access Tunnel
30. Lander Crew Cabin
31. First Stage Ascent Vehicle Propellant Tanks
32. Ascent Vehicle Engines
33. Exhaust Deflector Plates
34. Landing Engines & RCS
35. Landing Legs (4 off)
36. Heat Shield
37. Parachute Stowage
38. Thermal control Radiators
39. Secondary 1.5 m Antennae (3 off)

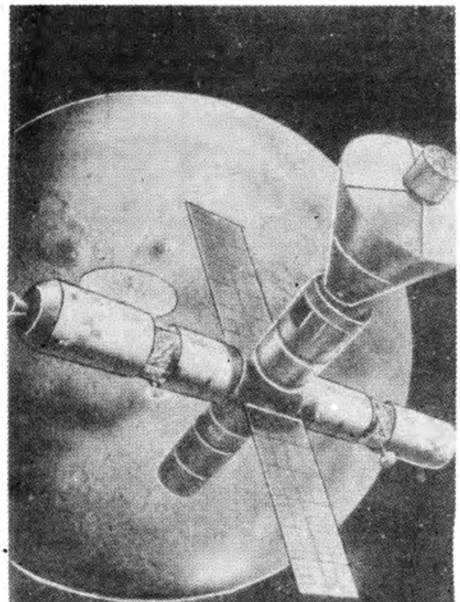






MAIN COMPONENTS

A - 30 t. Orbital Transfer Stage
B - Orbiter 1 Module
C - Docking Module
D - Orbiter 2 Module
E - Interorbital Transfer Vehicle
F - Stores Module
G - Lander



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MANNED MARS MISSION 1995

R.C. Parkinson 18.6.81

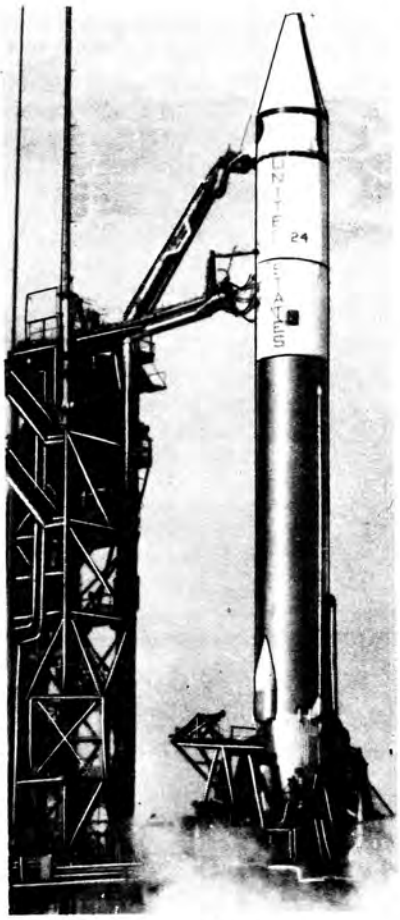
MAN ON MARS - A BRIEF CHRONOLOGY

1925
Walter Hohmann, in *Die Erreichbarkeit der Himmelskörper*, outlines the minimum energy orbits for interplanetary travel, and thus lays the groundwork for engineering design of future missions.

1948
V. Cleaver and L. Shepherd publish a series of papers on "The Atomic Rocket" in the *BIS Journal*, laying the foundations for nuclear propulsion in space.

1952
W. von Braun publishes *Das Marsprojekt*, which describes the construction of ten. chemically-fuelled rocket ships in orbit about the Earth capable of carrying seventy men on a three-year mission to Mars, including up to 400 days on the Martian surface. The fleet would have required some 950 launches of a huge Earth-to-Orbit ferry rocket bigger than Saturn V. In 1956, with Willy Ley (*The Exploration of Mars*) he scales this expedition down to just two ships and twelve men. These are the first complete engineering studies of a mission to Mars.

1955
Project Rover is started as a joint venture between the US Atomic Energy Commission and the US Air Force to investigate the prospects for nuclear rocket propulsion.



Mariner 9 launcher pad test.

NASA manned mission 1969.

Oct. 1960
USSR attempts to launch first space probes to Mars. At both attempts the launch vehicles fail to achieve Earth orbit.

1961
Ernst Stuhlinger proposes plans for a manned Mars mission using nuclear-electric propulsion. His proposal would have constructed five 360 tonne vehicles in Earth orbit carrying a crew of fifteen and three landing vehicles on a 572 day round trip, with 29 days on Mars. Later studies show the powerplant mass to be unrealistically low.

May 1961
President Kennedy recommends the start of the NERVA nuclear rocket project. Contracts are awarded to Aerojet-General and Western Electric for the development of a 120 kN thrust, 1.1 GW engine. First hot firing of KIWI-B reactor takes place late in the same year.

Nov. 1962
The USSR spaceprobe Mars 1 is successfully launched towards Mars and passes within 193,000 km of the planet, but fails before encounter at the midcourse manoeuvre.

1963-4
R.L. Sohn and W.M. Hollister independently discover a class of round-trip orbits which use a Venus swing-by on either the outbound or inbound legs to reduce both flight times and delta-V requirements for a manned mission to Mars, improving considerably over Hohmann's original plan. These orbits become the basis for future planning.

Nov. 1964
Mariner 4 is launched to become the first successful fly-by probe of Mars. Encounter takes place on 14 July 1965 when the spacecraft comes within 9600 km of the surface and observes a heavily cratered surface but no canals or free water.

1967
M.W.J. Bell publishes a Rocketdyne study for an evolutionary programme of manned interplanetary exploration using chemically-propelled vehicles launched by the Saturn V rocket. Missions would have required rendezvous and assembly of interplanetary vehicles in Earth orbit. At this time there are a variety of studies underway for future expeditions to Mars as part of NASA's forward planning.

1969
The President's space task group advises launching a manned mission to Mars "before the end of the century" as part of future US activity in space. Earliest possible dates would have been in the early 1980's. NASA publishes plans for an Integrated Space Transportation System in which the preferred Mars mission profile uses two identical vehicles based round the nuclear NERVA stage for a 12 man expedition carrying out 30 days of exploration on the Martian surface in a total round-trip of about 560 days. Lander would have used Apollo technology or a lifting-body vehicle to give a greater choice of possible landing sites.

1971
Among studies for possible manned Mars missons, R. R. Titus proposes a "Fly-by, Excursion Mode Lander" (FLEM) vehicle as a means of achieving an early landing. The main vehicle does not stop at Mars, but an "excursion module" is detached a few weeks before encounter to go on ahead and carry out the landing. FLEM missions would have required only two Saturn V launches to carry out.

May 1971
USSR probe Mars 3 is launched. This probe successfully ejects a small lander which continues transmitting until 20 seconds after reaching surface, but owing to the presence of a planetwide dust storm at the time no useful information is returned from the surface.

May 1971
Mariner 9 is launched to become the first successful Mars orbiter, beginning a detailed survey of the Martian topography in Jan. 1972. It discovers *Mons Olympica, Vallis Marineris* (to which it gives its name), and evidence of free water run-off channels created in the not too distant past in some areas.

Phobos as seen by Mariner 9.

1972
NERVA development cancelled. NASA abandons plans for manned missions to Mars.

1975
Plans for a robot surface-sample-return probe based on Viking hardware are published in the AIAA magazine *Aeronautics & Astronautics* as a follow-on in the exploration of Mars.

August 1975
Viking 1 launched to make a successful landing on *Chryse Planitia* on 20 July 1976. Viking 2 follows less than a month later. The Viking mission, originally planned for 90 days operation on and about Mars, continues making observations until late 1979 with a high degree of success. The entire surface is photographed to a resolution of 200m and a significant fraction at resolutions down to 8m.

The Martian surface - the first picture taken by Viking 1 after landing.

The orbiters also make close encounters with the two Martian moons, obtaining the highest resolution pictures ever taken of another object from a robot spacecraft.

1978
Twenty-seven scientists from the post-Viking Mars Science Working Group identify a wide-variety of missions for future Mars probes, but give highest priority to surface sample return missions.

1980
R. C. Parkinson presents paper *"Is Nuclear Propulsion Really Necessary? (or Mars in 1995!)"* at the AIAA 16th Joint Propulsion Conference, showing that manned missions to Mars are possible using a chemical propulsion in the Shuttle era. Results of the detailed "feasibility study" are presented at BIS Symposium on "Space Transportation Systems for the 1990's" in April 1981.

1981.
A four-day conference on manned Mars exploration under the title *The Case for Mars* is held at the University of Colorado sponsored by the University of Colorado Space Interest Group, the Planetary Society, the Viking Fund and the National Space Institute. The consensus is that "a Manned Planetary Program will provide both a unifying symbol and a future objective for the United States space program."

Continued from p.307

1960's. The mission would be assembed in low Earth orbit from a number of Shuttle launches, and depart for Mars on about 4 November 1994. Instead of the two vehicles proposed in the 1970 NASA plans, this mission would have three - two 'Orbiter' vehicles and one vehicle carrying the Lander and associated cargo on a one-way trip to Mars. The two Orbiter vehicles would provide living space for the five-man crew and give a 'mutual lifeboat' capability in the event of a major system failure. During the long periods of 'cruise' the three vehicles would dock together into a cruciform configuration (see centre pages) to allow the crew to move freely between one section and the next.

Each Orbiter vehicle consists of a single long Spacelab module fitted out to give the crew separate quarters and to provide life support and a control centre, with a half-length Pallet carrying additional equipment. One of the Orbiters would carry most of the scientific and communications equipment and a crew of three, while the second Orbiter would carry the Docking Module, which also carries the fold-out solar array providing power for the mission during the long periods of cruise.

At launch, each Orbiter vehicle has three propulsion stages. The first - a Heavy Boost stage the size of Saturn IV-B - accelerates the vehicle onto its transfer trajectory towards Mars. The second and third stages are nearly identical, and are based around the Shuttle Orbital Transfer Vehicle. The second stage parks the expedition in a 13½ hr orbit about Mars, and the third is used for departure from Mars orbit and return to Earth.

The Lander vehicle uses the same first and second stage boosters as the Orbiter vehicles, but omits the third stage. Furthermore, because the Lander assembly is lighter than the other two, the second stage booster actually has spare propulsion capability when it reaches Mars orbit, and can be used to pick up the returning surface exploration team, and carry out a side mission to Phobos. In addition to the manned Lander, the Lander vehicle will carry a communications relay satellite for the period during which the expedition is in Mars orbit, and three robot Surface Sample Return probes capable of lifting kilogramme-sized samples of soil back into orbit for sites not visited by the main expedition. One of those sites is expected to be a location on one of the Martian icecaps (see *Spaceflight,* 1976, p.383).

The expedition will arrive in orbit about Mars on 10 June 1995. It has 45 days in which to select a landing site, carry out a landing, field the SSR probes and carry out a side visit to Phobos. Then the two Orbiter vehicles will leave Mars orbit, not directly to Earth but to swing-by Venus on the way home.

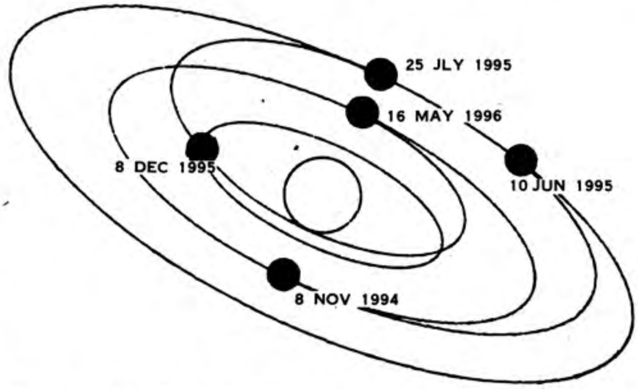
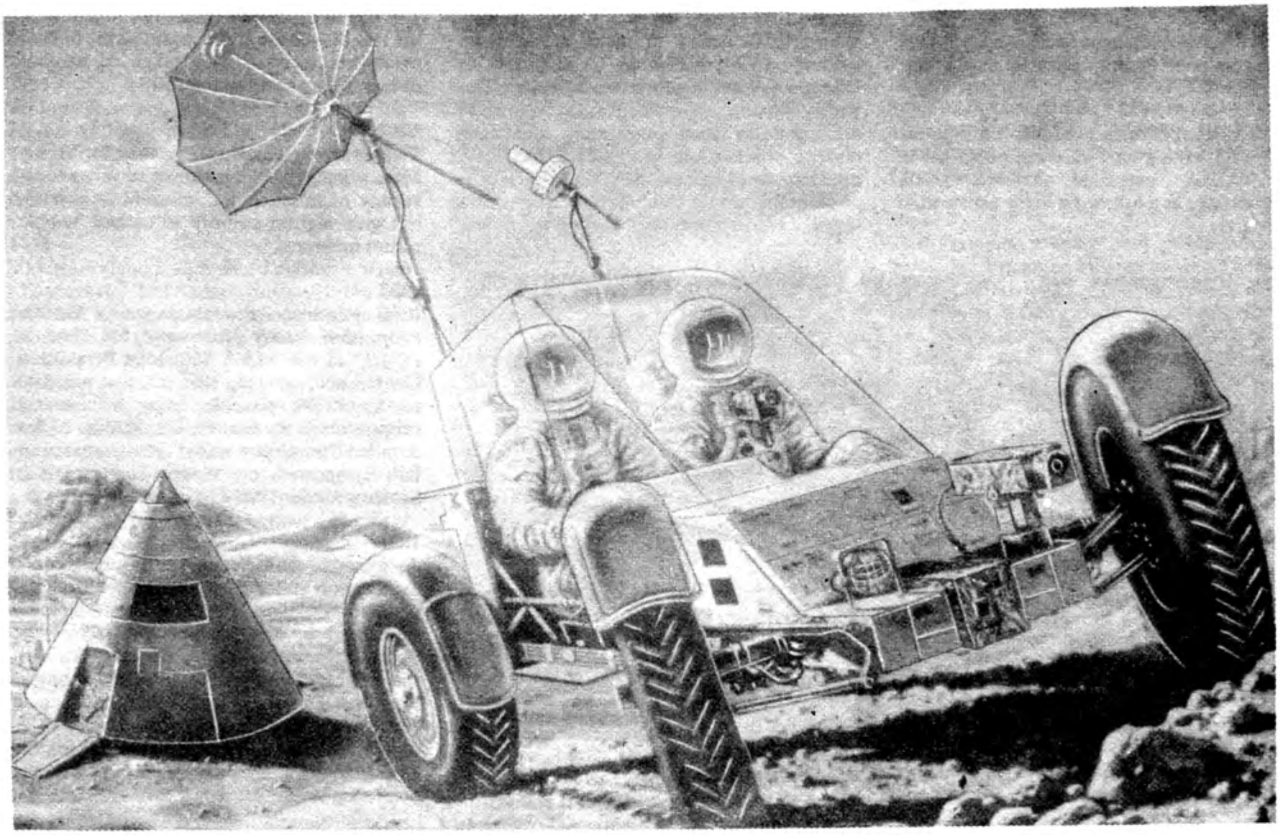


Diagram of the Earth-Mars-Venus swingby-Earth round trip planned for the mission. The Venus swingby means time and propulsion savings over a direct Earth return.



Landing site - Mars 1995. The lander has made a successful touchdown using a combination of aerodynamic and rocket braking. A large communication antenna has been set up and a drilling rig started, and now two members of the expedition are setting out in the Mars Rover for more distant points.

Close approach to Venus would occur about 8 December 1995, and would allow the mission to launch two Pioneer-sized entry probes at that planet. Then the orbit swings away from the Sun again and returns to Earth about 16 May 1996. The Venus-swingby trajectory is a plan worked out for the NASA nuclear mission, and saves both time and delta-V by shaping the trajectory closer to the ideal tangent as it encounters Earth for the second time.

Lander

The manned Mars Lander follows conservative principles by using the experience of Apollo and Viking for the capsule design. Shaped like Apollo, the capsule uses aerodynamic braking for the first part of the descent, using the minimal available lift and the capsule's RCS system to guide the flight path towards the precise chosen touchdown point. At 10 km altitude and a speed of Mach 2.5 the capsule releases a supersonic drogue parachute to bring it to subsonic speeds before deploying the main parachute canopy. It is now 4 to 5 km above the surface and has a descent speed of 60 m/sec.

.....the manned mission is....less than five times the cost of Viking....[with] a value at least an order of magnitude greater....

With deployment of the main parachute, the Lander will jettison its heat-shield and deploy its landing legs. For the first time the crew will have a clear view of the terrain below (this may require periscopes or under-belly mounted TV cameras) and be able to select their landing site. When you consider that this really needs to be somewhere 'interesting' like the *Vallis Marineris* it is apparent that the crew need considerable control at this point to make a safe landing. Finally, at about 600 m above the surface the landing rockets will be ignited, the parachute cut free, and the vehicle will manoeuvre for a conventional 'hot helicopter' landing.

On board the Lander the crew of three will have about 500 kg of scientific supplies and an advanced version of the Lunar Rover to take them several kilometres away from the landing site in the course of their 20 day stay. At the end of that stay a two-stage ascent vehicle mounted in the centre of the Lander will carry them and 300 kg of samples up to the waiting Orbital Transfer Vehicle for recovery.

Cost

The immediate reaction of most people to such an ambitious mission is "wouldn't it be terribly expensive?" And so it would be if we had to develop all the components of the mission specially. However, the point of basing the study on units already planned for other purposes was to minimize the need for 'special equipment' as far as possible throughout. The major component which would be specific to the mission to Mars is the Lander - and even here I have drawn heavily of Apollo and Viking experience.

If we cost only the hardware used and the development of those mission-specific components like the Lander, the total cost is surprisingly modest. In 1980 dollars it comes to about $5000 million. In the same units the Viking spacecraft cost $650 million a shot, so that the manned mission is actually less than five times the cost of Viking. In terms of scientific achievement the manned mission must have a value at least an order of magnitude greater than Viking, and so it may be that by the 1990s something that spaceflight fans have always known will have come true - it will actually be cheaper to do it with men!

ASTRONOMICAL NEWS

By J. S. Griffith*

EXTRA-SOLAR PLANETS

Detection of Planets

Astrometric observations of the positions of three red dwarfs within 6 pc did not detect any planets of the size of Jupiter or larger.

For over 40 years astronomers at the Sproul Observatory, Swarthmore College, Penn., U.S.A. have been photographing the positions of nearby stars. In [1] the results of the analysis of observations of three close red dwarfs, Wolf 294, Groombridge 1618, and Ross 128, are discussed.

The long-term stability of the Sproul 61 cm refractor is evident from the lack of detection of any planetary effects for many stars.

Of the 46 stars or systems within 5 pc, about half have been under 40-year surveillance at Sproul. Several have given evidence of substellar or planetary masses [2]. There is a large fraction of negative results. This is consistent with the predicted distribution. Of course, there may be a large number of planets with masses less than Jupiter which await new methods or longer intervals of observation. To aid the detection of planets between 1 and 60 Jupiter masses, it is pointed out that if one other observatory had been doing similar intensive coverage over the past decades, then more may have been discovered.

[1] Hershey, J. L., Borgman, E. R. and Worth, M. D., 1980, 'Three 40-year intensive Sproul plate series and planetary detection capability and probability,' *Astrophys. J.*, **240**, 130-136.
[2] Lippincott, S. L., 1978, *Space Sci. Rev.*, *22*, 153.

STARS

A Giant Filamentary Shell

In the large Megellanic Cloud there is a giant filamentary shell, N51D. It is probable that this is a supernova remnant approaching fossilisation.

There are many giant filamentary shells in the Large Magellanic Cloud (LMC). N51D is about 176 × 113 pc and has a thermal origin radio continuum [1]. The dynamics and structure were investigated by observing the profiles of the (O II) emission lines over the area, using the SRC 1.2m Schmidt and a Spectrograph on the 3.9 Anglo-Australian Telescope.

N51 appears to be a roughly spherical, ionised and neutral, shell expanding at about 35 kms^{-1} towards the observer and 25 kms^{-1} into perhaps a denser medium, away from the Earth.

Such shells can either by "bubbles" caused by energetic stellar winds from the enclosed supergiant OB stars or supernovae remnants approaching fossilisation.

Several other giant shells exist in the LMC and in the SMC.

[1] Meaburn, J. and Terrett, D.L., 'The dynamics of the giant filamentary shell'.

Algol

A comprehensive analysis of previously published observations of Algol (B Per) is presented.

Algol is an intensely studied object. It has a B8 V primary and a G-type secondary in a $2^d.87$ orbit. This close binary is attended by an Am component in a 680^d orbit.

In [1] a re-analysis of previous observations is presented, with Table 8 giving the orbits and Table 9 the physical data of the components. The two orbits are found to be coplanar with opposite senses of revolution. Period changes as high as 10^{-5}P apear to result from transfer of mass and angular momentum, leading to a figure P of 10^{-7} solar masses a year with a steady flow of matter from the secondary. There are still discrepancies, both in relative luminosities and in trying to deduce the evolutionary history.

[1] Soderhjelm, S., 1980, 'Geometry and dynamics of the Algol system', *Astro. and Astrophys.*, **89**, 100-112.

The Shape of Nova Remnants

The elongated appearance of many Nova remnants is explained in terms of rapid rotation of the parent white dwarf giving spin angular momentum to material ejected in the equatorial plane. The white dwarf rotation periods deduced from the shape are of the order of minutes, consistent with direct observations.

In [1], it is noted that remnant shells left by novae have a generally elliptical shape with equatorial rings and polar blobs. The elongated shape is explained in terms of conservation of angular momentus as the parent white dwarf ejects the remnant shell.

From the ratio of equatorial to polar axes and from typical nova ejection velocities, the rotation period of the white dwarf is found to be of the order of minutes, consistent with observations [2,3].

[1] Fiedler, R. L. and Jones, T. W., 1980, 'White dwarf rotation and the shapes of nova remants,' *Astrophys. J.*, **239**, 253-256.
[2] Walker, M. F., 1956, *Astrophys. J.*, **123**, 168.
[3] Patterson, J., 1979, *Astrophys. J.* (Letters), **219**, LIII.

The Frequency of Supernova

Radio remnant studies seem to imply a galactic supernová rate of once every 60 to 150 years, while studies of historical supernovae, other spiral galaxies, and pulsars all suggest a rate of about once every 15 to 30 years. This discrepancy is explained by the existence of a hot tenuous interstellar gas decreasing the lifetime of supernova remnants so that a large fraction of the observed radio remnants are much younger than they were thought to be, and the rate of supernovae required to produce them is correspondingly greater.

In [1] it is pointed out that the existence of such a hot tenuous gas implies that the local situation as evidenced by soft X-rays and UV line observations is representative of most of interstellar space.

[1] Higdon, J. C. and Lingenfelter, R. E., 1980, 'Supernova remnants and the filling factor of the hot interstellar medium,' *Astrophys. J.*, **239**, 867-872.

Globular Cluster in Centaurs A

A 17th magnitude object in the halo of the radio galaxy NGC 5128 (Centaurs A) is identified as a globular cluster.

The closest of the large radio galaxies is NGC 5128 (Centaurus A). On photographic plates taken with the 4m telescope at

**Lakehead University, Thunder Bay, Ontario, Canada.*

Cerro Tololo Inter-American Observatory [1] a slightly diffuse 17th magnitude object was detected. Spectrophotometric observations indicate that, as it has an energy distribution characteristic only of stars, a bright star cluster is being observed, between 8 and 16kpc from the NGC 5128 nucleus. It has a linear diameter of between 35 and 70 pc. The integrated spectrum has no strong blue-violet continuum due to young stars and no emission lines, suggesting an age of more than 10^8 years. However, even though it has been suggested that NGC 5128 has been formed by the massive addition of gaseous material to a basically normal elliptical galaxy about 10^9 years ago and that the compact stellar nucleus of the smaller galaxy survived the impact, it is unlikely that the object being discussed is indeed that one. Its velocity relative to NGC 5128 is far too small.

[1] Graham, J.A. and Phillips, M.M., 1980, 'The first bright globular cluster in NGC 5128,' *Astrophys. J.* (Letters), **239**, L97-99.

GRAVITATIONAL RADIATION

Cosmological Gravitational Waves

A cosmological background of gravitational radiation could be primordial or have been generated at some finite time in the past (for example, by the formation of a number of black holes). Using the parameters of wave density and characteristic period, the effects of the waves on the dynamics of the Universe are discussed.

In [1] it is pointed out that various types of gravitational radiation may exist. From a supernova and gravitational collapse we would obtain a burst of radiation; from binaries and pulsars we expect continuous radiation; there may exist background radiation. The possible origins of such radiation are graphically depicted in [1].

Six possible scenarios for black hole formation are listed. Large density fluctuations at the start of the Universe could lead to black hole formation within the first few moments of the big bang. If the early Universe were cold or tepid, the production of black holes is much more probable. In the usual hot scenario, it is possible that a number of black holes formed after decoupling. From a number of very massive stars evolving quickly we obtain a number of black holes well before galaxy formation, and after galaxy formation massive population III stars could form black holes. Entire galaxies may collapse into black holes (mass less than 10^8 solar masses). All these lead to holes with between 10 and 10^8 solar masses.

The characteristic periods and density of gravitational waves produced by the various scenarios are discussed.

Any primordial black holes with mass less than 10^{15} would have evaporated by now [2]and a small percentage of their mass energy may have been transferred to black body gravitons.

Primordial radiation will in general control the dynamics of the Universe at an early stage, making it anisotropic. If the cosmic abundances of helium and deuterium result from cosmological nucleosynthesis, then there are limits on the characteristic wavelengths of primordial gravitational radiation.

Gravitation radiation generated at a later date has density which can never exceed the density of the holes which produce them, so they can never be dynamically important.

[1] Carr, B. J., 'Cosmological gravitational waves: their origin and consequences,' 1980, *Astron. and Astrophys.*, *59*, 6-21.
[2] Hawkins, S. W., 1974, *Nature*, **248**, 30.

The Barred Spiral Galaxy NGC 1398.
Anglo-Australian Observatory

GALACTIC ASTRONOMY

Barred Galaxies

The relationship between the stellar structure of barred galaxies and the bar itself is discussed. A bar can change both stellar content and stellar dynamics.

Barred galaxies have larger axial ratios and a qualitative difference between their major and minor-axis profiles, with a sharp outer edge to surface brightness along the major axis. The surface brightness decreases steeply along the minor axis. Further discussion of the distinct components in barred galaxies is given in [1], which also contains a section on theoretical N-body computations.

From observational evidence it appears that bars are dynamically different from elliptical galaxies. Secular evolution in barred galaxies may produce an exponential disk from the disk stars by heating by the bar. The bar may evolve into a lens. Feeding of the disk gas by Seyfert nuclei may result in nuclear activity.

Even though our understanding of bar dynamics is far from complete, the author of [1] has the encouraging feeling that the subject is making rapid progress and that we now have a good picture of what further observations and theory are needed to develop our understanding of the dynamics of barred galaxies.

In Magellanic irregular spiral galaxies containing prominent bars (like the Large Magellanic Cloud) the most active sites of star formation are found to occur near the ends of the bars.

The authors of [2] studied 44 such galaxies and found that those with bars having solid-body rotation had their most intense H II regions near the ends of the bars, possibly as a result of the increased gas compression there. *30 Doradus* may have formed as a result of such compression in the Large Magellanic Cloud.

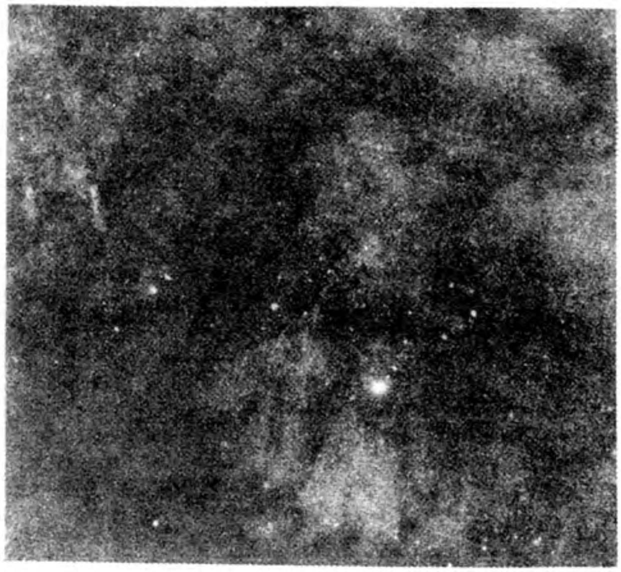
[1] Kormendy, J., 'The structure of barred galaxies,' 1980, to appear in *Structure and Evolution of Normal Galaxies*, ed. S. M. Fall and D. Lynden, Bell, Cambridge University Press.
[2] Elmegreen, D. M. and Elmegreen, B. G., 1980, 'The location of star-forming regions in barred Magellanic-type galaxies,' *Astron. J.*, **85**, 1325-1327.

The Galactic Centre

The compact nonthermal radio source at the galactic centre is the smallest known radio source in a galactic centre and is unusually steady. It lies midway between the two main classes of compact nonthermal radio sources — stellar and nonstellar. It is modelled using relativistic outflow, either spherically or in jets.

In Ref (1) it is pointed out that it is unlikely that the source is associated with a black hole. Five models are constructed and it is concluded that a number of dynamically self-consistent models of incoherent synchrotron sources can fit observations. It is suggested that the object is a pulsar passing through a dense cloud. Additional observations (in particular interferometric observations at higher frequencies) are needed to determine the source, size and shape, measurements of the X-rays flux would be useful, as would investigation of the nuclear radio sources in nearby spirals.

[1] Reynolds, S. P. and McKee, C. F., 1980, 'The compact radio source at the Galactic Centre,' *Astrophys. J.*, **239**, 893-897.



The Milky Way in the region of Opniucnus.

Quasars

High-redshift objects (some quasars) associated with NGC 2859 are discussed.

An explanation for the observation of high-redshift quasars physically associated with low-redshift galaxies is put forward in terms of quasars being ejected from galactic nucleii. Quasar alignments and redshift bunching are satisfactorily accounted for.

Quasars are much more likely to be found near galaxies which are companions to larger galaxies than in a general field [1]. Companion galaxies were tested in the NGC 2441 to NGC 2968 region of right ascension. The case of NGC 2859, which had quasars next to three out of four of its companions, is discussed. The pattern of associated discordant redshifts in galaxies and quasars is one which has been met before.

In an explanation of this phenomenon, the authors of Ref. [2] use the Hoyle-Narlikar theory of gravitation, which is based on Mach's principle. In this theory every particle in the Universe derives its inertia from the rest of the particles in the Universe. From this theory the equations of motion of a quasar radically fired from a galaxy are derived and solved. The quasar is fired with a near-light speed but slows to non-relativistic speed, eventually stopping and falling back. This radial oscillation continues in decreasing amplitude. It is suggested that bound quasars are those which show up as members of anomalous-redshift quasar-galaxy type combinations, whereas free quasars are those which had escape velocity.

If multiple quasar creation takes place in a single explosion, then quasars have similar redshifts. With conservation of momentum we necessarily have alignments near galaxies. Multiple ejections at different epochs lead to quasars with bunched redshifts.

The higher the redshift, the younger the quasar. From the redshifts of the quasar and parent galaxy their relative electron masses may be determined.

The redshift dependence of particle masses in a quasar should show up in its luminosity.

Quasar matter is made up of particles of lower mass than found in ordinary matter.

[1] Arp. H., 1980, 'High redshift objects near the companion galaxies to NGC 2859,' *Astrophys. J.*, **240**, 415-420.
[2] Narlikar, J. V., and Das, P. K., 1980, 'Anomalous redshifts of quasi-stellar objects,' *Astrophys. J.*, **240**, 401-414.

ON THE FORMATION OF A GLOBAL SPACE AGENCY

By Ian Crawford

The achievements in the exploration of space which we have seen over the past two decades have been mainly along national lines. What could we achieve if the entire world worked with common goals? The author considers the possibility of establishing an international space programme.

Introduction

There is, today, a pleasing amount of international co-operation in space research. Perhaps the European Space Agency is the best example of such co-operation because, although it consists of a relatively small number of member states, they co-operate, or are prepared to co-operate, in a wide range of projects. Other organisations, such as Intelsat (the International Telecommunications Satellite Consortium), operate in a limited area of space technology but draw together many more nations; Intelsat has over 100 member states. The purpose of this article, however, is to look at the far more ambitious possibilities regarding the formation of a global space agency which would have responsibility for all aspects of space research.

Global Co-operation

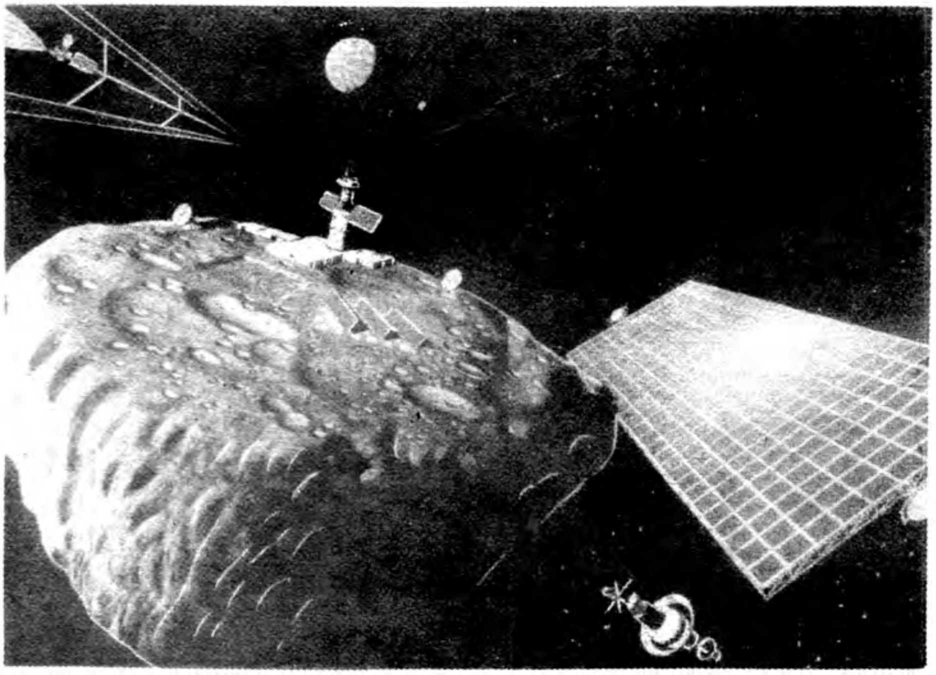
Much as we might like to pretend otherwise, it is a fact that many of the World's great space projects are undertaken for political purposes and many of the lesser ones for military ones. For these reasons it is perhaps naïve to expect total international co-operation in space research; indeed, it might be argued that, by removing the element of political competition, such a system would severely reduce the pace of astronautical developments. I shall argue, however, that this need not be so; that there is no difficulty, in principle, in establishing a global space agency and that, when the full advantages are realised, there should be few political reasons why it should not be established in reality.

The organisation of today's World is increasingly dependent on space technology, particularly in the field of telecommunications where the existence of Intelsat clearly shows that many nations regard co-operation here as highly important. As time goes on, more and more space-related developments will become important to the World's economy and the placing of these under international control would be beneficial to all. It is important to realise that this will not apply only to unmanned Earth satellites but, in the not-too-distant future, to manned activities as well. The maintenance of many separate international bodies, each to take care of a separate field of study, makes little economic sense and both the finance and organisation would, in my view, be better placed in the hands of one agency. I can see few reasons why most countries would not agree to some form of international control over all civilian and scientific space projects; military questions, as always, are more delicate.

Until recently military satellites were employed either for early-warning and surveillance or for communications. Surveillance satellites could logically be controlled by the proposed agency, on behalf of the United Nations, to monitor compliance with international treaties. Their observations would be made available to all nations and only those intending to deliberately violate such treaties could object to this arrangement. Military communications satellites pose a more complex problem since, as long as nations wish to maintain independent military machines, they will insist on the use of these satellites and their exclusive control. In the envisaged system these would have to be launched by the international agency according to some agreement acceptable to all parties.

Recently, both super-powers have started thinking about more active military roles in space and the development of so-called killer satellites has probably already begun. This is obviously a very dangerous situation and must be brought under control in the near future. If this trend is allowed to continue much further then asking a nation to place her space interests under international control would be like asking her to do the same with her air force — not something that would appeal to the average politician. Perhaps a global space agency is necessary if further military exploitation in this field is to be prevented.

I envisage such an agency being responsible ultimately for all space projects and being answerable to the General Assembly of the United Nations. Each of the 'developed' nations would contribute a relatively small percentage of their GNP, in a manner similar to the present financing of ESA. Many poorer



A montage of possible future space projects, all of them so large that they may need cooperation on a world scale. They include asteroid mining, space colonies, solar power satellites and, not shown here, permanently manned bases on the Moon and Mars.

nations, of course, would be unable to afford to subscribe to the agency but, through the United Nations, would be guaranteed any scientific, technological and social benefits which resulted from its work. The direct economic benefits, which would result from industrial contracts, would be shared out between the contributing nations in a way linked to their subscriptions.

There would, in my view, be many advantages in the formation of such an international body, of which a demilitarisation of space would be only one. It would enable more funds to be made available for space research than is currently possible and would prevent the duplication of work carried out by different nations, thus leading to a better utilisation of resources. Perhaps the greatest benefit of all would be the reduction of international tensions that co-operation at this level would, hopefully, bring.

Many will argue that international competition is necessary if space technology is to advance at the pace to which we are accustomed. I believe that this need not be so; the member countries of ESA have agreed to pay sums of money to an organisation which manages projects of little political value and I can see no reason why most other nations should object to this. With guaranteed funds available the developments would probably proceed at a faster rate because they would be driven not by the whims of politicians but by the enthusiasm of the scientists and engineers concerned. Funds would no longer be restricted for projects which are of great scientific importance but which have little political or military usefulness.

The above should not be taken to mean that all competition would be ended. Competition will be of great importance in driving the exploration and exploitation of space; all that will be ended is *international* competition driven by political considerations. As the industrial development of the Solar System continues, companies will be formed which deal exclusively in space technology and, later, in space exploitation; mining and construction, for example. Competition between these companies will, as always, reduce prices and, hence, speed up the rate of development. What is important is that this will be competition between companies rather than between nations. By this time the central agency would be directly responsible only for the scientific missions and would act as a guard to prevent nationalism once again creeping in.

Perhaps the best example of international cooperation so far is the Apollo-Soyuz Test Project when Soviet and American crews flew a joint space mission. It showed that, if the political will is there, the technical problems are secondary. Here we see President Ford meeting the Soviet crew *(left)* and their US counterparts.

Perhaps all this is a naîve view, but I have tried to show that the concept of a global space agency should not be dismissed out of hand. Anyone who has a true picture of Earth's place in the cosmos must be struck by the futility of national differences and the absurdity of trying to break out of our 'cosmic cradle' on a national basis. The formation of one body to take responsibility for this task, on behalf of humanity as a whole, is surely the most logical way to go about it. In spite of the political and bureaucratic difficulties, is this not something for which we should strive?

The Editor would welcome readers' responses to the suggestions put forward by Mr. Crawford. Is a global space agency possible in the real World? How would we overcome the awesome political differences?

On a more general note, short items on interesting topics in the above style will always be considered for publication by the Editor.

SALYUT 6 MEDICAL MONITORING TECHNIQUES

By Joel Powell

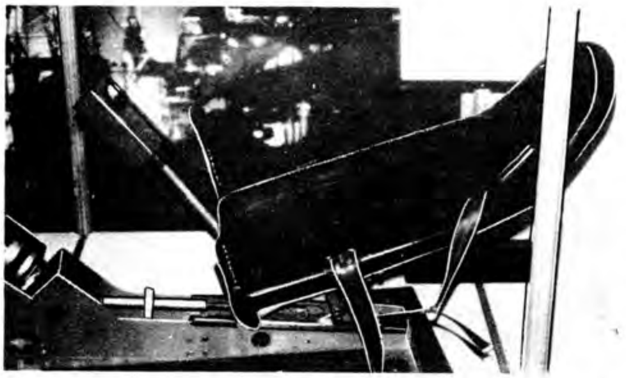
Introduction

The study of the weightlessness adaption of the Soviet cosmonauts who occupied the Salyut 6 space laboratory was conducted primarily with the "Polinon 2M", "Rheograph 2" and "Beta" apparatus. The equipment and their procedural modes provide insight into the Soviet's approach to the study of zero-g and its effect on the human organism.

Polinom 2M

The "Polinom 2M" apparatus is basically a versatile electrocardiograph. The device is used for what the Soviets call three "programmes" of cardiac monitoring. The *first programme* is described as a simple electrocardiographic examination using twelve standard electrode contact points. The *second programme* is a study of the phase structure of the cardiographic cycle in weightlessness. This is accomplished by recording the femoral arterial pulse, performing a kinetic cardiogram and conducting measurements with a pressure cuff attached to the cosmonaut's arm (called a "tacho-oscillogram"). The *third programme* is recording cardiograms at compression of the vessels around the tibia, at the right jugular vein (called a "phlebogram") and at the carotid and radial arteries (called "sphygmograms").

In previous spaceflights, American and Soviet researchers discovered periodic bioelectric deviations on spaceflight electrocardiograms. To study and determine the nature of the deviations, the Soviets developed a portable "Kardiokassetta" instrument to continuously record EKGs for up to 24 hours (for the 175 day expedition). The Soviets believe that positional and metabolic changes in the myocardium (the muscle of the heart) are responsible. The technique is called "dynamic electrocardiography".



The Veloergometer exercise aboard Salyut. One of the pedals can be seen at extreme left.

Neville Kidger

Rheograph 2

Whereas the Polinom measures the action of the heart, the "Rheograph 2" measures blood flow in the weightless body. Rheograms are done at the head, torso, forearm and the crus.

The Rheograms of the head are conducted with a special helmet that holds 1 cm diameter "silver laminated" electrodes. For the trunk and limbs the 1 cm electrodes are attached with a plastic band having cloth fasteners.

Blood fill rate of the crus was measured by placing a pressure cuff on the lower third of the femur. A manometer (bulb) was used to inflate the cuff in graduated amounts. As the crural vessels are compressed the blood flow is electrically measured. On the resulting graph the rise of the curve reveals the blood flow rate. Calibration was performed before the test with a syringe to inflate the cuff so that changes in blood flow volume were measured. The process is called "occlusive plethysmography".

The cosmonauts also utilize a device to measure the volume of the crus. Eight different levels each separated by 3 cm were measured on the crus by a measuring tape on top of an elastic band. According to the Soviets, the volume is derived from the hypothesis that truncated cones are formed in each of the segments marked off by the measuring tape. The total of seven truncated cones on a 24 cm section of the crus yields the volume.

The crus was chosen specifically as a convenient point to study the action of the heart in the extremities of the body. Crural volume was measured periodically throughout the flight.

Beta

The "Beta" instrument is an electrocardiograph that covers indices not measured by the Polinom 2M. The Soviets describe its function as "to record an electrocardiogram using a zonal system of fixing the electrodes and sensors at the 'DS' contact point." At the same time a "turbine-type sensor" is attached to the cosmonaut by a mask to record a pneumogram (assessing lung function) and another sensor records a seismogram of the heart to determine the rhythm and force of blood being pumped into the vessels.

These instruments are used with the cosmonauts at rest or doing physical exercise on the bicycle ergometer or the treadmill, also known as the comprehensive physical trainer. Exercise began on the 140 day expedition on the fifth day.

Medical monitoring is also performed when the cosmonauts are using the lower body negative pressure suit, called the "Chibis". Electrocardiograms, arterial pressure measurements and phlebograms (see above) are performed during "Chibis" use. The suit provides from 10 to 45 mm of Hg negative pressure. On normal sessions four pressure settings are used, and up to eight just before return to Earth. Sessions during the 140 day flight were begun every four days 18 days before return, and the more strenuous sessions were conducted every two days beginning six days before touchdown.

The "Penguin" 2 and 3 muscle-loading suits were worn for 16 hours every day to help maintain the cosmonauts' muscle tone during flight. Such prophylactic measures are part of the medical experiments, which are intended to gauge adaptation to weightlessness and to discover how much conditional deterioration can be prevented. The cosmonauts performed a thorough medical check on each other during the 175 day mission every eight to ten days *(Spaceflight,* **22,** April 1980, p. 146).

Measurement of body mass is an important parameter in the space medical experiments, so the Soviets installed a massmeter on Salyut. To use the device, located on the "ceiling" of Salyut 6, the cosmonaut takes a "lying on the stomach" position with the feet placed in footboards. The head is fixed in position by an adjustable chin support. One hand is placed on a control lever. The other cosmonaut tightens the moveable part of the device into a low fixed position by means of a handle at the base. With fingertip pressure on the "flip-flop catches", the Soviets state, the moveable portion begins to oscillate in a period determined by the mass of the cosmonaut (derived by calculation). The cosmonaut being measured would also hold his breath and tighten his muscles.

Calibration was done before the procedure by recording the period of oscillation of a calibrated mass. The Soviets reported that on the second (140 day) expedition, mass measurement was begun on the fourth day and was performed daily by day eleven, later decreasing to once every two weeks.

A Possible Future Development

The next step in Soviet space medical experiments may be the use of a centrifuge by the cosmonauts. The Soviets have indicated in a Novosti news agency article that "artificial gravity is a promising means of preventing adverse effects of zero-g in extended space flights" (*Space World*, June-July 1980, vol. Q-6-198-199, p. 19), based upon their centrifuge studies on the Cosmos biosatellites. The amount and duration of artificial gravity, they said, would have to be determined by tests on humans.

It is possible that a future Salyut could carry a small experimental centrifuge, perhaps located where the BST-1M telescope or the MKF-6M camera now reside. It is more likely that a centrifuge will be included in the planned permanently manned space station expected in 1985. Conditions would be more suitable for the inclusion of a centrifuge in the larger facility where more power and facilities are available.

Sources

"Results of Medical Studies During long-term Manned Flights of the Orbital Salyut 6 and Soyuz Complex", A. O. Yegorov, compiler, NASA TM-76014, Nov. 1979; NASA microfiche N79-33231, translation of "Salyut 6: Our Commentary", by A. Burnazyan, *Pravda*, Sept. 5, 1979, p. 5.

SATELLITE DIGEST - 149

A monthly listing of all known artificial satellites and spacecraft. An explanation of the information presented can be found in the January 1979 issue, p. 32.

Robert D. Christy

Continued from October issue

Name, designation and object number	Launch date, lifetime and descent date	Shape and weight (kg)	Size (m)	Perigee height (km)	Apogee height (km)	Orbital inclination (deg)	Nodal period (min)	Launch site launch vehicle and payload/launch
GOES 5 1981-49A 12472	1981 May 22.937 indefinite	Cylinder 400	3 long 2 dia	35451	37010	0.52	1458.71	ESMR Delta NOAA/NASA (1)
Intelsat 5 (2) 1981-50A 12474	1981 May 23.946 indefinite	Box + 2 panels 1065		geostationary orbit				ESMR Atlas Centaur Intelsat/NASA (2)
Rohini 2 1981-51A 12491	1981 May 31.21 8 days	Spheroid 40	0.5 dia	187	418	46.27	90.49	Sriharikhota SLV-3 India/India (3)
Cosmos 1274 1981-52A 12495	1981 Jun 3.58 30 days (R) 1981 Jul 3	Cylinder + sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	170	353	67.16	89.75	Plesetsk A-2 USSR/USSR (4)
Cosmos 1275 1981-53A 12504	1981 Jun 4.65 1000 years	Cylinder? 700?	2 long? 2 dia?	962	1012	82.96	104.91	Plesetsk C-1 USSR/USSR (5)
Molniya-3 (16) 1981-54A 12512	1981 Jun 9.15 12 years?	Cylinder-cone+6 panels? 2000?	4.2 long? 1.6 dia?	434 442	40843 39913	62.81 62.81	736.56 717.78	Plesetsk A-2-e USSR/USSR (6)
Cosmos 1276 1981-55A 12517	1981 Jun 16.29 13 days (R) 1981 Jun 29	Cylinder+ sphere+ cylinder-cone? 6000?	6 long? 2.4 dia?	214	237	82.37	89.06	Plesetsk A-2 USSR/USSR (7)
Cosmos 1277 1981-56A 12520	1981 Jun 17.40 14 days (R) 1981 Jul 1	Cylinder+sphere + cylinder-cone? 6000?	6 long? 2.4 dia?	207 375 360	377 407 416	70.41 70.41 70.40	90.40 92.42 92.36	Tyuratam A-2 USSR/USSR (8)
Meteosat 2 1981-57A 12544	1981 Jun 19.524 indefinite	Cylinder? 312.5	3.20 long 2.10 dia	geostationary orbit				Kourou Ariane ESA/ESA (9)
Apple 1981-57B 12545	1981 Jun 19.524 indefinite	Cylinder+nozzle + 2 panels 380	1.985 long 1.20 dia	geostationary orbit				Kourou Ariane ISRO/ESA (10)
Cosmos 1278 1981-58A 12547	1981 Jun 19.82 12 years	Cylinder-cone + 6 panels? 2000?	4 long? 1.6 dia?	615	40214	62.84	727.39	Plesetsk A-2-e USSR/USSR (11)
NOAA 7 12553	1981 Jun 23.454 400 years	Irregular box + panel 723 (empty)	3.71 long 1.88 dia	844	862	98.90	102.05	WSMR Atlas F NOAA/NASA (12)

SUPPLEMENTARY NOTES:

(1) US meteorological satellite in synchronous orbit above 85 degrees west longitude.
(2) International communications satellite in synchronous orbit above 1 degree west longitude.
(3) Indian-launched and built small scientific satellite.
(4) Manoeuvrable, long life reconnaissance satellite.
(5) Navigation satellite.
(6) USSR communications satellite. Orbital data are at 1981 Jun 10.2 and 16.3.
(7) Reconnaissance satellite carrying an Earth resources package.
(8) Orbital data are at 1981 Jun 17.4, 18.1 and 19.1.
(9) European meteorological satellite in synchronous orbit above the Greenwich meridian.
(10) Indian-built experimental communications satellite in geosynchronous orbit above 102 degrees east longitude. Apple (Ariane Passenger Payload Experiment) was carried aboard the third test flight of Ariane which put Meteosat 2 into orbit. Press reports indicate that one of the solar panels has failed to deploy.
(11) Early warning satellite.
(12) US meteorological satellite in polar orbit sending back cloud cover photographs and other atmospheric data.

AMENDMENTS:

Cosmos 1249, 1981-21A completed its mission on 1981 Jun 19 and the nuclear reactor was boosted into an orbit of 894 × 963 km, 65.00 degrees, 103.60 min.
1980-43A, the name should be NOAA-B as the mission was unsuccessful.
Cosmos 1270, 1981-45A was recovered 1981 Jun 17 after 30 days.

MAPPING THE PLANETS AND MOONS

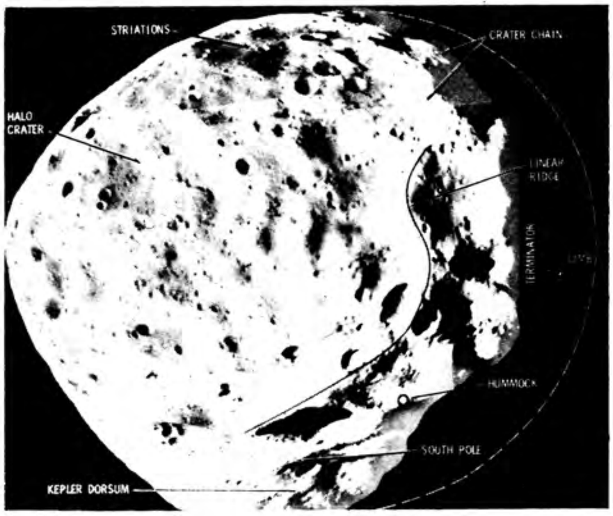
By Geraint Day

One of the principal agencies concerned with the production of maps of the Moon and planets using space mission data is the United States Geological Survey (USGS). When the USGS was founded back in 1879, even the pioneers engaged in mineral surveys and geological structure investigations must have had little or no notion that, less than a century later, the boundaries of exploration would have been pushed back some hundreds of millions of kilometres.

However, with the events of NASA in late 1958 and subsequent interest in manned landings on the Moon, the skills of the USGS map makers were set to work on several extraterrestrial tasks. Using painstakingly-obtained visual photographic observations of the Moon made by Earth-bound astronomers, R. J. Hackman drew up the first true photogeological lunar map in 1961. Many charts of the Moon had been made by then of course, beginning with those of Galileo and Thomas Harriot in 1610. But Hackman's work, later developed by E. M. Shoemaker, laid the basis for lunar geological mapping and an understanding of the Moon's stratigraphy (i.e., how the various rock units are laid in superposition relative to one another).

This understanding of the USGS led, *via* the USA's Ranger, Surveyor and Lunar Orbiter programmes and their detailed orbital and ground-level imagery of the Moon, to the Apollo series itself. The newley-available spacecraft images were added to the telescopic record and even maps of individual craters could be drawn. The USGS now has over 70 lunar charts available for sale to the public. These range from a geological map of the Earth-facing side at a scale of 1:5,000,000 (1 cm representing 50 km), down to geological maps of individual features such as the bright, rayed crater Copernicus, at a scale of 1:1,000,000. Most of these geological charts are based on remote sensing information.

Many of the maps are, literally, works of art. As well as the geological charts there are many shaded relief maps, with airbrush representation of topography (such as the map of the Moon's *Mare Orientale* region). Artists such as P. M. Bridges and J. L. Inge produce the magnificent renditions.

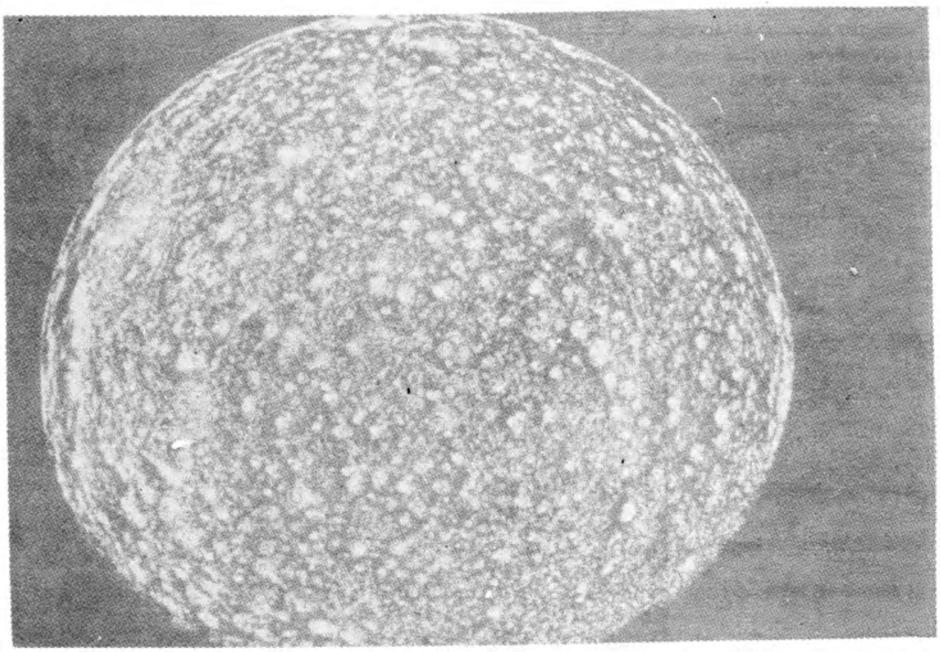


The Planets

The scene was set for missions to the planets by the experience gained in lunar mapping. There are currently a dozen charts of Mercury (including a reference photomosaic) based on the Mariner 10 photographs of this cratered world. Since Mars is better known, about 100 maps are devoted to the Red Planet. These comprise topographic, shaded relief and geological maps, plus various photomosaics. The Galilean satellites of Jupiter (Io, Europa, Ganymede and Callisto) are also depicted on four preliminary pictorial charts derived from the Voyager 1 and 2 pictures. Another USGS project is a map of Venus based on radar studies of the planet, both from Earth and the Pioneer Orbiter. Saturn's system studied by the Voyagers has also come under scrutiny by the photogeologists.

Another sign of the times is the fact that the USGS produces satellite image maps of Earth. The United States Geological Survey has come a long way since the days of mapping out the resources of the Wild West.

The US Geological Survey sells maps at very reasonable prices. Lists may be obtained and maps ordered from: Branch of Distribution Eastern Region, United States Geological Survey, 1200 South Eads Street, Arlington, Viginia 22202, USA.



Left: even the Galilean satellites of Jupiter have been the subject of mapping. This is a 9-frame mosaic of Callisto taken by Voyager 2 in July 1979 at a distance of 242,000 miles, and images such as this are used for producing preliminiary maps. *Above:* the tiny inner moon of Mars, Phobos, has been observed with increasing resolution. Telescopes show it as no more than a point of light but Mariner 9 in 1972 and then Vikings 1 and 2 have allowed us close views of its surface.

SAFETY PRACTICES FOR SOYUZ RECOVERIES

By R. D. Christy

Introduction

The use of Soyuz as a man-carrying space vehicle began in April 1967 with Vladimir Komarov's fatal one day flight. To date, around forty crews have been carried to or from orbit by various versions of the craft, and more than twenty flights have taken place under various parts of its development programme. The large number of manned missions has provided a wealth of statistics for the outside observer which, taken together with information provided directly by the Soviet Union, allows a fairly close study of the application of basic mission rules.

There has always been a tendency for Soyuz landings to occur in the second quarter of the day (GMT), a fact which has been noticeable to observers from a very early date. It was taken as an indication of the Soviets' desire to ensure daylight landings, with a preference for local afternoon over the morning in the landing area. Other than this type of casual observation, no definitive explanation of how mission planners chose recovery and launch dates was available until 1973, when technical details of the Apollo Soyuz Test Project flight profile began to become available.

One document in particular [1] contained details of the basic conditions which govern the choice of Soyuz missions' launch dates and times. Retrospective analysis of successful manned Soyuz flights reveals that the conditions have been applied fairly rigidly to flights over the whole period that Soyuz has been operating, but starting after Soyuz 1.

Two constraints are applied to the conditions under which a Soyuz is to return from orbit. They must be obeyed, on the day of recovery, for one of the orbital passes over the recovery area. The constraints are:

"1. The landing must take place at least one hour before actual sunset in the landing area.

2. Prior to the firing of the retro-rocket, the requirements of the manual orientation system must be fulfilled, i.e. the time from crossing the Earth terminator to the retro-fire must be at least eight minutes" (sic).

Normally, these requirements are required to apply to the first pass over the landing area on the chosen landing day and on the following (reserve) day. Unfortunately, in the case of ASTP, the Apollo and Soyuz safety conditions were mutually exclusive, so the Soviet side agreed for that mission only to change the application of the safety constraints to the third orbit over the landing area.

Soyuz Landings

Owing to the rotation of the Earth beneath a satellite orbit, the ground tracks of successive orbits move progressively westwards; in the case of Soyuz by about 23 degrees each pass. The majority of Soyuz landing locations have clustered around a point near to 50 degrees north, 70 degrees east which is near to the northern apex of the 51.6 degree inclination Soyuz orbit. Consequently, it is possible for a Soyuz to set down in that area from any particular orbital pass which has a northbound equator crossing between 20 degrees east longitude and 48 degrees west, over a period of four and a half hours as the Earth rotates. The first pass over the area, as described in the landing constraints, would be a 20 degrees east equator crossing. The third pass, as defined for ASTP, would be an equator crossing around 25 degrees west longitude. To date, Soyuz 11 holds the record for the furthest west reentry track, setting down in the normal area from an equator crossing at 42 degrees west.

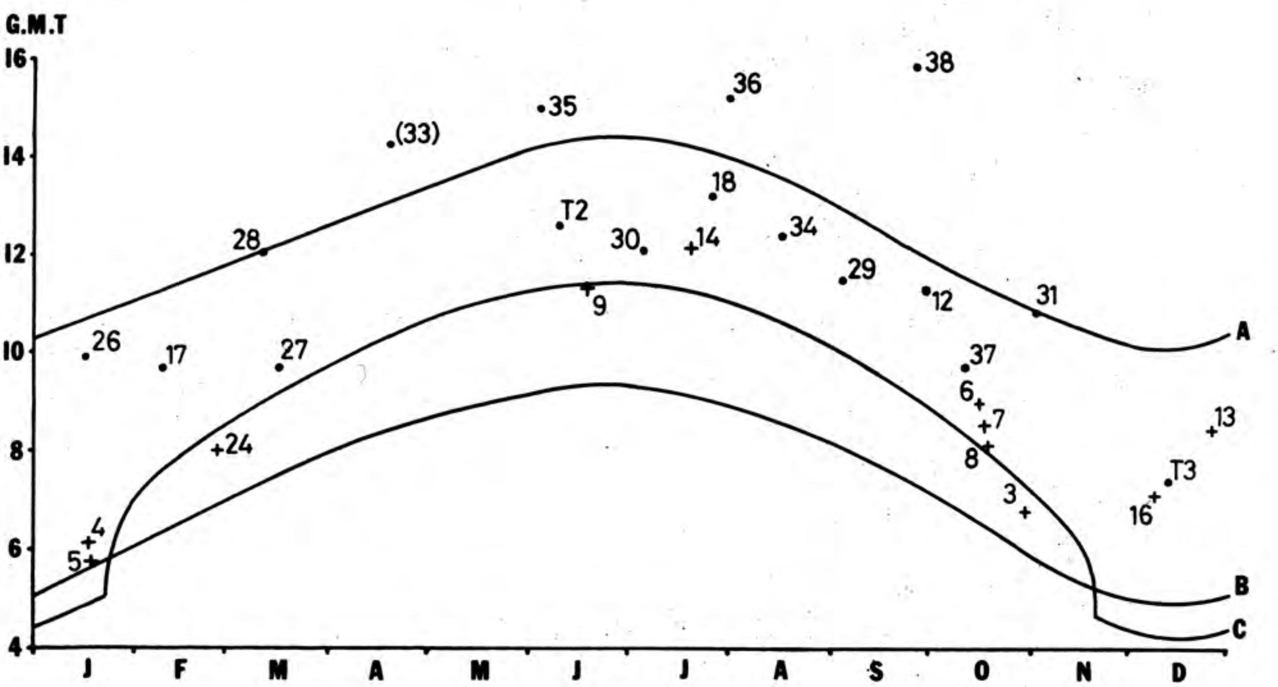


Fig. 1. Illustrates the change in the Soyuz landing constraints through the year. Curve A represents one hour before sunset in the landing zone. Curve B marks the earliest possible landing time from 225 km while obeying the second constraint. Curve C is a similar representation for a 350 km orbit. The points plotted are the landing times which Soyuz craft would have achieved if the equator crossing on the final orbit were 29 degrees east. Crosses represent orbits around 225 km and dots those around 300-350 km. Excluded are Soyuz 19 (ASTP - see text), the docking failures (15, 23, 25 and 33, although a projected point is shown for the last of these, craft which failed to complete full duration missions (10, 11 and 21), unmanned landings (2, 20, 32 and T1), Soyuz 22 (65 degrees inclination), and Soyuz 1 (see text). The plot is complete up to the end of 1980.

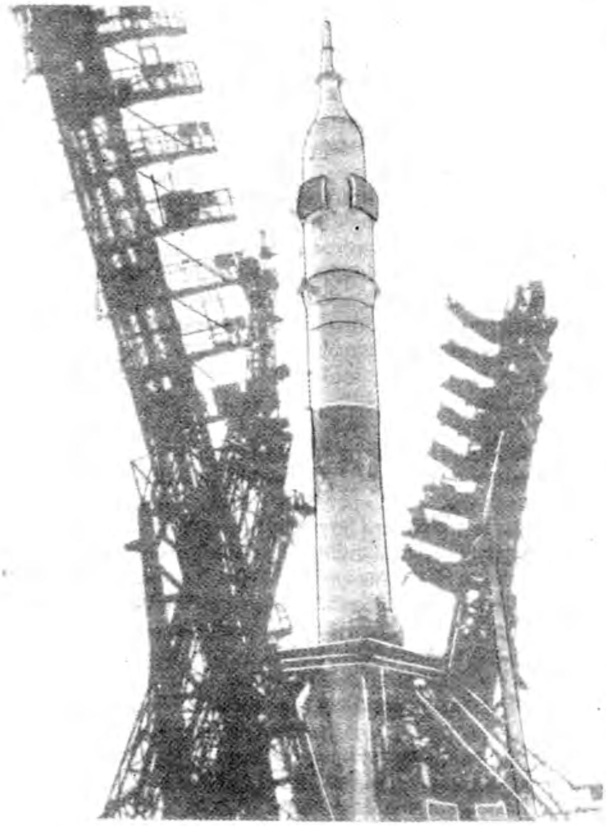


Fig. 2. The ASTP flight gave us the first details of Soviet manned recovery procedures. The Soyuz 19 launcher is seen here on the pad three days before lift-off.

Interpretation of the Constraints

The effect of the second constraint on a Soyuz landing time depends on the height from which a Soyuz is returning to Earth. The lower the orbit, the shorter the period between retro-fire and landing, hence the further north along the final ground track is the point of retro-fire. In the case of a Soyuz returning from around 350km (e.g. from Salyut 6), retro-fire occurs near to latitude 43 degrees south. The early test flights of Soyuz (e.g. Soyuz 4, 5, 6 etc.) orbited at altitudes just above 220km, and retro-fire took place near to latitude 28 degrees south. Figure 1 contains two lines representing the second constraint, one for each of the two orbital heights.

Although the constraints are applied to the first possible landing orbit each day, there is not a strict requirement for the Soyuz actually to return to Earth on such an orbit. Of the two, the first constraint is flexible; for example, although Soyuz 28 would have landed just one hour before sunset from a 20 degrees east ground track, it actually landed in darkness after crossing the equator at 5 degrees west, one orbit later.

Because of the Earth's rotation from west to east, it follows for the Soyuz orbit that as long as both constraints are fulfilled on the first orbit of each day, the second constraint will be obeyed on all possible landing orbits on that day, even though the actual landing might take place in darkness. The constraints are designed to ensure that in the event of a manually navigated reentry, the crew have time to make necessary sightings and computations, and the recovery crews on the ground have time to locate the returning craft visually before the sun sets.

Soyuz 1

Independently of the Earth's rotation, the plane of a satellite orbit rotates in space about the Earth's polar axis. The Soyuz orbit completes one rotation with respect to the Earth-Sun line every eight weeks, and during that period the constraints are obeyed, on average, for about one week. Consequently, it is possible to look critically at the Soyuz flights which are known not to have completed their planned flights, and project them forward into the landing "window". The results of doing this are in reasonable agreement with those derived empirically by Phillip Clark [2].

There is only Soyuz 1, of the 51.6 degrees inclination flights, for which it is not possible to do this and arrive at an acceptable answer. The location of Soyuz 1's orbit plane may have been chosen to maximise the power available from the solar panels, while ensuring a landing around dawn, local time. One consequence of such a choice would be that the whole recovery sequence would have to take place in total darkness with no visible horizon. The outcome of enquiries into the Soyuz 1 accident probably led to the introduction of the two constraints. Evidence for this conclusion lies in the fact that the next manned flight, Soyuz 3, was the first to obey them.

Salyut 6

Four of the flights returning from Salyut 6 during 1979 and 1980 obeyed the retro-fire safety requirement but fell outside the first constraint. They were Soyuz 33 (projected forward to an eight day flight), Soyuz 35, Soyuz 36 and Soyuz 38. The reasons for these are obviously open to debate. That for Soyuz 35 was certainly the immediately following flight of the new Soyuz-T2. Soyuz 38's early landing was probably dictated by the need to fly Progress 11 up to Salyut and to follow it with the recovery of the long stay crew (Popov and Ryumin) in the October 1980 "window". The thinking behind the other two remains obscure at present, though there is no suggestion that they returned early as a result of their missions being curtailed. Both were carrying International crews back from a standard eight day flight.

One feature of the Salyut 6 missions has been the occasional transfer of a Soyuz from the rear docking unit to the forward one in order to allow a Progress supply craft to dock and transfer fuel (only the rear unit on Salyut 6 was equipped with the necessary fuel pipe connections). All such transfers have taken place during periods when the landing "window" was open, apparently to ensure that should the Soyuz be unable to redock it would be able to navigate its reentry under ideal conditions.

Salyut 6 was originally intended to operate for eighteen months from its launch in September 1977, taking it up to the end of the first quarter of 1979. All missions since then have been a bonus in that its continued operation saved the launch costs of its successor. Starting with the February 1979 launch of Soyuz 32, all subsequent main crew launches have been timed so that they actually went into orbit during a landing "window", again ensuring that a shortened mission due to docking problems or inability to enter the station would be able to stage a well-managed recovery.

Conclusion

The apparent lessons of Soyuz 1 have been well learned. There is nothing to suggest that with the introduction of Soyuz-T and its navigational computer any changes have been brought about in the recovery constraints. Both Soyuz-T manned missions during 1980 obeyed the normal Soyuz recovery rules, so hopefully the sport of calculating Soyuz mission durations at the moment launches occur will live on.

REFERENCES

1. "Apollo Soyuz Test Project — Launch Window Plan," ASTP Mission Document 40100.2, October 1973.
2. Clark, Phillip S., "Soyuz Missions to Salyut Stations," *Spaceflight*, **21**, 6, pp. 259-263 (1979).

SOCIETY NEWS

UP, ALOFT!

Dr. Bob Parkinson has been promoted to the position of Superintendant, Propellants 1 Branch at the Propellants, Explosives and Rocket Motor Establishment (PERME) Waltham Abbey, with effect from August 1981.

Bob is an active member of the BIS, serving as a member of the Council from 1970 onwards, and has contributed a number of studies on the feasibility of early colonies on the Moon exploiting lunar resources. He was a member of the BIS *Project Daedalus* team, contributing to the concept of mining the atmosphere of Jupiter for Helium-3. Recently he has been involved in studies of the feasibility of manned missions to Mars in the 1990's.

In 1979 he wrote the text to *High Road to the Moon,* using the pictures of R.A. Smith to illustrate the ideas of the early pioneers within the Society and how they turned out in fact. He also contributed the chapter on "Lunar Colonies" to the recent *Illustrated Encyclopedia of Space Technology* edited by Ken Gatland.

Dr. R.C. Parkinson.

Bob Parkinson joined the sister Establishment to Waltham Abbey at Westcott (then the Rocket Propulsion Establishment) in 1965, initially to work on the problems involved using liquid hydrogen for space vehicle propulsion. Later he worked on systems studies involving the use of Resistojet electric propulsion for communications satellites, and solid propellant apogee stages for satellites as well as a number of non-space-orientated projects. From 1965 he was Head of the Design and Evaluation section in the Solid Propellant Motors Division at PERME Westcott.

He is married and has a two year old son.

PLEASE ACCEPT OUR THANKS

The Council wishes to record their thanks to the Directors of Western Glass International of Basingstoke, Hants, for their very valuable gift to the Society of 96 lead-crystal glasses and, particularly, to Mr. Wally Horwood for his good offices making this gift possible.

LIBRARY REPORT

Keeping up the Pressure

The good news is that the Society has been able to move away from relying on the purely fortuitous receipt of material and for some time now, has been identifying and seeking out rare, specialised or otherwise unique material. So far, we have been very successful and the flow of material of this nature now coming in is most satisfying. The task involved an appraisal of hundreds of book-sellers' and publishers' catalogues, of reviews in various magazines for some years past, comparison with collections in other libraries and even the physical examination of the stocks of certain bookshops!

This is not to say we didn't meet with disappointments. Some books no more than a few years old turned out to be unavailable or out of print. Some turned out to be far too expensive to acquire: some, though desirable in themselves as being of historical interest, could not be obtained because they were not directly and immediately relevant to our aims.

The operation really had to be geared to a way of obtaining books for the library without being asked to pay for them, though, fortunately, it was never a policy of "beg, borrow or steal" because enormous support stemmed from the goodwill which the Society has created over many years past. Some donors were impressed with the sheer extent of our efforts (or possibly the sheer cheek of it!) and, generously, decided that we deserved help.

This last has probably been the key to our success. So many have seen the work and enthusiasm which has carried us along and, even if not members of the Society themselves, have responded magnificently, so much so that we anticipate that the value of the books and other items received this year will approach a value of nearly £10,000.

STC DISCUSSION

Another "briefing" meeting for members of the Space Technology Committee, designed to evaluate areas of future study, took place at HQ on 2nd July, with arrangements in the hands of three Council Members i.e. Peter Conchie, Gerry Webb and Bob Parkinson.

About 30 attended to hear the following short papers:-

1. Remote Sensing by P.A. Roberts
2. Economic Basis for Space Colonisation by T.J. Grant
3. Space Insurance by R.A. Buckland
4. Proving the Commercial of the Space Habitat by A. Clark
4. Space Exploration by R.C. Parkinson

All papers were followed by lively technical discussions.

Another year of concentrated work will be needed to plug most of the gaps we still have, but most semi-historical items nowadays can be obtained only on purchase and will have to await some distant date when our Society has money to spare. But even if this doesn't happen, it might well be that the work being done now might provide a stock of historical items for the future.

Among the Donors......

Arthur Clarke, always a busy man, hit on a novel idea to let us know which books he was willing to donate. He simply photographed the whole lot in his bookshelf! Unfortunately, this struck a rock because not all books are titled on the spine: consequently, our magnifying glass was able to identify only a fraction of them.

Not to be put off, Arthur shipped the whole lot to us!

Our appeals also wrung the heart of Deane Davis (now sunning himself in Hawaii), so much so that his gift included a selection of NASA badges for various past launchings, ideal for showing off when we get a new display case. Admittedly, Deane's gift is more real than the display case to put them in - the latter is just a gleam in the eye at present. His badges, however, set us thinking that this could become a marvellous collection. We have added a few more since and will keep an eye open for others. We hope members will do so, too.

John Marelli of Charlestown, Massachusetts, has been recovering from a bad illness of late (get well soon, John!) but he still made it to get a letter off to us with a wide range of items to choose from. We accepted, of course, but not without a bad attack of conscience, for John has enough on his plate right now, without the chore of adding to his load.

David Fearn provided a fine collection on Ion Propulsion, while Alan Bond gave his all on Advanced Propulsion. Phil Bono turned out his unique collection on Reusable Rockets while Mr. Burkitt produced some early Rolls-Royce material on Blue Streak. Sandwiched among this was a very good selection of material on the Space Shuttle, brought back by the Executive Secretary who suffered a severe list to port as a result of it and complained of back trouble interminably afterwards.

We also continued to seek good technical books from Publishers, many of whom responded with great charm and sent books even when their Review lists had long since closed. For our part we were delighted with the result and have continued to prepare notes on books received for the Reviews Sections of both *JBIS* and *Spaceflight*. Once again, Ray Ward helped us to locate the lesser-known publishers; many of the books of the greatest interest to us are published in very small print-runs and are circulated to few other than to those directly interested in the particular topic.

By and large, however, in the absence of a magic wand, the Library is being built up by a long and continuing process which involves masses of correspondence, personal appeals, searches and the compilation of innumerable Reviews for both *JBIS* and *Spaceflight*. Each generally results in one extra book residing on our shelves and so gradually, almost imperceptibly, the whole is taking shape, though there are still many sections still at "deadrock" proportions which need the infusion of classic and standard reference works.

Some Statistics

At the last count, our stock totals were as follows:

Books	1800
Periodicals	3700
Total	5500

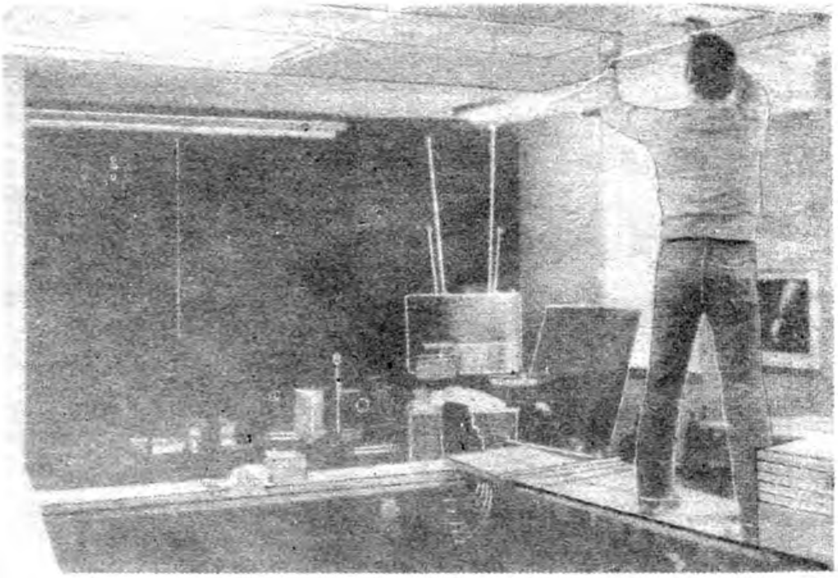
We (or rather, Colin Ledsome) also undertook the task of measuring shelf space to try to give us an idea of what we needed in terms of thickness. Whether he was referring to the thickness of book or of the Committee was not clear at the time but our hackles slowly lowered when we saw he was genuinely measuring the shelves.

Books	58
Reports	35
Periodicals	24
Brochures & Pamphlets	16
Total	133 Metres

Keeping Track

At long last our new Index Cabinet arrived. It brought a new lase of life to those concerned with preparing and filing away the index cards but, unfortunately, was not to be installed without a hiccup. The cabinet, on arrival, was found to be too short for the stand: instead of fitting snuggly and firmly, it had a pronounced tendency to slide, or even to tip through the hole in the centre!

The matter was tackled with a suitable array of hacksaws,



TOPWISE!

The Council recently authorised the inclusion of a suspended ceiling to improve both the accoustics and appearance of our Conference Room.

At the same time the opportunity was taken to install ventilator fans for each of the windows and to alter the electrics to provide "dimming", to avoid the abrupt and disconcerting changes in brilliance as lights are switched on and off.

The entrance step into the Conference Room, previously tiled to match the floor of the room itself has now been given a surround in a different colour. This draws attention to its existence and reduces the danger that Members, entering in darkness while a meeting is in progress, might have missed the warning notice and momentarily forgot to "mind the step!"

wrenches, screwdrivers and expletives, none of which proved really necessary; one had simply to unscrew the old supports and replace with those of the right size!

Modelmania

The Library Committee has also received models of the Saturn V Rocket (on loan) and Space Shuttle (to keep!). A suitable display case is being prepared by Pat Ladd to enable both models to be put on show by the Library entrance.

Pat is also being pressed into service to provide a matching display cabinet for the one we already have, and which will be used to exhibit more artefacts - assuming that our efforts to secure such items meets with success.

First Day Covers

We would very much like to collect and exhibit a selection of first day covers on suitable space events. Some have already been donated to us, (Rex Hall, particularly, turned up trumps), so other members with material of this sort which they would like to present to the Society can be sure that their gifts will be much appreciated.

Curiouser & Curiouser

Cataloguing seemingly endless piles of books is clearly a chore, yet it seems to have its brighter moments. By all accounts, members of the Committee are on the lookout for titles which, though apparently innocent, lend themselves to other interpretations, thus, "Activities in Space Biology" become known as "Breeding your own Astronaut" and Brian O'Leary's book "The Making of an *ex*-Astronaut" had them on the floor. The NASA publication "Introducing Children to Space" was turned into "Via the Airlock", Heinz Gartmann "The Men Behind the Space Rockets" became "Why Can't We See Them?", and Eric Burgess, of course, disclosed clear criminal intent with his "Assault on the Moon". The famous article by Mr. Tomkin on attitude control is, naturally, "The Tomkin Wobble-Stopper" but reserved among all - and that after many years now - is Orford's famous "Lens Work for Amateurs" - described invariably and ruefully as "Len's Work for Amateurs".

VISITATION, OR VISIT?

A recent visitor to HQ and looking Summery in the pouring rain, no doubt because he was hot-foot back to the steaming jungles of Sri Lanka, was Arthur Clarke. At least, we *think* we saw him. The visit was so quick that it was reminiscent of a tour drive to the Meteor Crater in Arizona some years back where we streamed out of the coaches, faced the setting sun and a strong headwind which peppered our faces with sand, and then streamed back again - in a matter of moments and, to this day, argue whether we actually *saw* the Meteor Crater or not.

Arthur, or perhaps an echo of his voice, made it clear that he, henceforth, would have no time to read any mail, which left us pondering how an expert on enhanced communications had managed to negative the whole purpose of his greatest achievement.

Dimly, to the roar of his car speeding away, we remembered that there had been things to ask him, documents to sign, photographs to take and a host of things to discuss and information to obtain. For one thing, we needed to check our memory against his on how his now-famous Paper on "Extra-terrestrial Relays" came to appear in *Wireless World* instead of the more logical *JBIS*.

But he was gone and, clearly, not coming back, nor apparently was he going to read any letters. There was only the telephone, and that was far too pricey.

It was just another problem. We reached out for the Gin bottle once more.

WELCOME TO THE CLUB!

Andy Wilson, who has worked part-time for the Society since December 1979, joined us on a full-time basis on 1 July. Much of his time is taken up with editing the *Space Chronicle and Space Technology* Journals and acting as Managing Editor of *Spaceflight* and *Space Education.*

Andy gained a degree in Astronomy from University College, London - a major factor in choosing UCL was that it was in the same city as the BIS! - in 1977 and then spent a year qualifying as a physics teacher.

He joined the Society in 1971 after becoming aware of our existence through the Brooke Bonde Tea "Race Into Space" series of cards! The quality of *Spaceflight* encouraged him to try his own hand at writing - his first article appeared in the March 1977 issue - and since then, he says, "my interest has continued to grow."

MEMBERSHIP CARDS

The Council has now approved the design of a Membership Card which will be distributed to all members, free of charge. The first card will be sent out with the January 1982 issue of *Spaceflight.* Thereafter, copies will be enclosed with the January issue of that magazine for each following year.

The new cards are plastic coated, printed in dark blue* on a light blue background and include the Society's logo on the front. The reverse contains provision for each member's signature and other details.

On receipt of the card, each member should complete these details, peel off the protective paper, press down the plastic cover and thus complete the lamination.

The Council has also arranged for the production of small handy wallets, embossed with the Society's logo, to contain the membership cards.

The wallets are available for 60p each (or $1) post free. If remitting the dollar, please send a dollar bill or the amount will otherwise be absorbed by bank charges!

Wallets can be ordered at any time. Provision for requesting them will appear on next year's annual subscription notice.

**Special cards, emblazoned in gold, will be issued to mark the Society's 50th Anniversary.*

SOCIETY MEETINGS

A TENTH PLANET?

The possibility of our Solar System having at least one more planetary member has long fascinated astronomers. Opinion has tended towards the negative side, though, because Clyde Tombaugh's thorough search about the eliptic while hunting for Pluto did not turn up any more bodies.

Tony Lawton, BIS Vice-President, addressed himself to the problem in his lecture "Planet 10 - A Gift from Galileo" given to the Society on 27 May 1981 and contested that there *was* a good chance of a tenth planet. Tombaugh's work has its limitations (he searched through 45 *million* stars!) and a dim, slow-moving body could easily have been overlooked. The Sun's significant influence goes out to some 600 AU and there could be another five or six planets waiting to be discovered.

When Neptune was discovered in 1846 - Mr. Lawton described it as a "planet born of maths" because of the analysis on perturbations in Uranus' orbit which went into determining its position - astronomers were able to look back over old records to search for previous sightings. Lalande, for example, saw Neptune in May 1975. The problem was that its position did not match up with post-discovery measurements: something has been perturbing Neptune's orbit. We all know the story of the discovery of Pluto - but that body is too small to have had the desired effect. In 1890, Lowell calculated that the unknown planet should be five to six times as massive as Earth. In fact Pluto has only ¼% of Earth's mass.

Recent dramatic developments have added more fuel to the fire.

It was calculated that Neptune occulted Jupiter in January 1613 and September 1702 and any records from those times may contain clues to Neptune's earlier positions. Sure enough, Galileo accurately noted the position of Neptune in December 1612 - 200 years before its 'discovery'! - and this allowed us to extend our knowledge of its orbit even further.

The essence of Mr. Lawton's suggestion is that a tenth planet passed relatively close to Neptune sometime in the past, pulled Pluto - a moon - out as a seperate body and generally disturbed the Neptunian system. Charon was torn from Pluto itself. Voyager 2 passes by Neptune in 1989 and we may well see evidence of such catastrophic events.

This unknown tenth planet could be in a long period orbit (990 years) with a perihelion which comes close to Neptune's path and the great distances involved could explain why Tombaugh missed it - it was too slow moving to show up much change in position.

We hope to publish Mr. Lawton's own account of this fascinatng subject in the future.

ROCKET PROPULSION

On 26 March 1981 at BIS headquarters, Martin Fry gave a fascinating talk to Society members on the subject of rocket propulsion. The lecture came about as a result of the recent rocket propulsion study course and it was intended to be both a review for those who had attended and also a complete talk covering the basic principles of propulsion for members who had not benefited from the study course.

The lecture began by examining the simplest and crudest system of propulsion - solid propellants. Indeed, they are still much in use today, from fireworks to sounding rockets and, of course, the solid rocket boosters of the Space Shuttle. Fuels used for solid rockets have a central core which burns rapidly, giving off a high density gas to produce thrust. Solid fuel rockets have very little control and once lit they have to burn out or, should a fault develop, be destroyed. However, solid fuelled vehicles have the advantage of being simple, relatively inexpensive, safer to handle and storable for long periods. Testing is expensive since the whole vehicle acts as the combustion chamber and has to withstand the high pressures incurred.

Martin Fry, Chairman of the Society's 'Rocket Technology' lecture series.

The bulk of the lecture was concerned with liquid propulsion. This system employs a combustion chamber into which liquid propellants, sometimes combustible on contact, are injected. Liquid propulsion vehicles offer far greater control than solid rockets basically by employing a gimballed thrust chamber which can be throttled to produce varying thrust levels. Various feed systems for the propellants were discussed, including gas generator systems and pump feed (the latter system being used on all large engines). Exhaust gases from the feed systems are usually discharged overboard but with the Space Shuttle the exhaust is fed back into the combustion chamber and expanded with the primary exhausts.

Slides shown covered rocket engines from Goddard's first rocket (which flew for several seconds on 16 March 1926 and landed in a cabbage patch) and V-2 engines to the F-1 of the Saturn V and the Space Shuttle Main Engine. To achieve the optimum performance from an engine the design of the combustion chamber, throat and nozzle is vital. By measuring the specific impulse against the area ratio (size of nozzle) it is possible to determine the optimum size of nozzle to achieve an identical ambient pressure and thrust pressure. Another problem encountered when designing a booster vehicle is that as the vehicle climbs the atmospheric pressure reduces, and the performance of the engine changes radically. The resultant design is a staged vehicle with the first stage designed to operate at lower altitudes and relatively high atmospheric pressures, and the second and third stages operating in low pressres or the vacuum of space. This was one of the critical problem areas to be solved when the Shuttle engines were designed since they have to operate during the entire launch until the orbital manoeuvring engines take over. Those who witnessed Saturn V launches will recall that just prior to staging an enormous plume could be seen emanating from the first stage engines. This, of course, was because the first stage engines were designed so that the optimum thrust ratio was achieved at near sea-level atmospheric pressures. After staging the plume disappeared since the J-2 second stage engine was designed for use in the upper atmosphere and vacuum and, as such, there was little wasted energy.

An examination was made of various engines to show how they have been developed over the years. The V-2 had a low specific impulse and a low area ratio; the Space Shuttle (since it has to operate in a vacuum) has very high chamber pressure and area ratios. It was clearly shown how the state of the art has developed rapidly as engine performance has had to be improved.

The lecture was concluded with an examination of Shuttle systems and flight parameters, and a look at future trends. The most exotic conception belonged to A. C. Clarke who in his book *The Fountains of Paradise*, suggested a giant elevator to orbit.

If you want to know more - read the book!

BOOK REVIEWS

Update on Space (Vol. I)
Ed. B. J. Bluth and S. R. McNeal, National Behavior Systems, 196pp. 1981 $7.95 softback

This is intended as the first volume of a series providing a view of man's exploration and utilization of space. It began as a summer course at the California State University in 1978 where speakers from the space industry outlined present and possible future plans to lay audience.

If it had been produced ten years ago the emphasis probably would have been on the "gee-whiz" aspect of space exploration but, with the purse strings now pulled tightly, it concentrates on practical benefits. Eight chapters, each by a different author, cover such topics as "Large Scale Human Benefits of Space Industrialization", "Materials Processing in Space" and "Space Shuttle and Solar Power Satellite Systems".

This is not a "nitty-gritty" book but is presented at a general level, eg. the chapter on "The Role of the Military in Space" is a little too general and reads rather like a press release.

Two chapters on the philosophical side wind up the presentation, the final one being of Krafft Ehricke's "The Extraterrestrial Imperative" articles. This alone, easily makes the whole book worthwhile.

The Quest for Extraterrestrial Life - A Book of Readings
D. Goldsmith, University Science Books, 308 pp, 1980.

Despite the lack of any positive evidence that worlds beyond the Earth are inhabited, scientists have long speculated about possible forms of life and communication among advanced civilizations in our galaxy.

In this book the author has prepared a collection of references on the possibility of life elsewhere in the Universe which range over the years. After an historical perspective, from Lucretius (about 70 BC) to Voltaire (1752), the text takes on a modern slant which extracts on the origin of life from Charles Darwin to Fred Hoyle. Simon Newcomb, an astronomer, comes rather well out of it, since one of his other beliefs, i.e the complete impossibility of heavier-than-air flight, is not mentioned!

The section of the search for life in the Solar System begins with an extract from *Mars as the Abode of Life* by Percival Lowell, which must have accounted, in some part, for the near-panic in America in 1938 following the fictitious 'Martian Invasion' radio programme by Orson Welles and which had them taking to the hills in droves.

The remainder of the book is much more up-to-date, including a fair amount on the search for Interstellar messages, e.g. Project Ozma, but going much beyond this, for example, there are several Papers on the theme of "Where is Everybody?' There is also a short piece containing a warning from Sir Martin Ryle that we should not be too brash in signalling our presence to what might prove to be hostile listeners.

The book provides a handy collection of views and much interesting reading, even though the texts have all appeared elsewhere. It is, however, mainly concerned with the philosophy, biology and astronomy aspects. The "Quest" described would become much more significant if part was related to Man's own efforts to venture into Interstellar Space with such studies as Project Daedalus. Unfortunately, none of this appears.

The Historical Supernovae
D.H. Clarke and F.R. Stephenson, Pergammon Press, 233pp. 1977, £5.25.

The impact of the study of historical supernovae on modern astrophysics has been very significant. Many of the most dramatic discoveries in recent years such as pulsars, black holes, X-ray binaries, etc. are directly linked with supernova explosions.

The vast majority of stars in a typical galaxy are very stable and their output of radiation over millions of years is remarkably steady. In marked contrast, the Novae and Supernovae are stars which spontaneously explode so that, at maximum, they rival the brightest stars in the heavens, before fading into insignificance again. At its brightest, a nova may be a million times as bright at the Sun; with a Supernova, it would be several thousand times as bright again and emitting as much energy as all the other stars in the galaxy combined.

After the opening chapter which explains the origin of Novae and Supernovae as far as is currently known, the main part of the text deals with the search for historical records of supernovae and supernovae remnants in observations going back to the early Chinese Dynasties.

Some particular novae are dealt with e.g. the Crab Nebula and the "New Stars" of Tycho Brahe and Johannes Kepler.

The book concludes with some thoughts on the evolution of supernova remnants.

The front cover shows a radio map of the remnant of the Supernova of A.D. 185, superimposed on a page of text from History of the later Han Dynasty describing the explosion.

This book is suitable for students interested in the history of science as well as amateur astronomers and many non-specialists.

Twenty-Five Years of the American Astronautical Society 1954-1979
Ed. E.M. Emme, AAS, 235pp, 1981.

This volume is not a fully-fledged history of the American Astronautical Society *per se,* but more of an anniversary-prompted collection of memoirs from some of the leading individuals who participated in its origin and growth.

This, in itself, is enough to guarantee an avid readership, for the AAS has been incredibly active over the years, as any collection of its publications will testify.

The AAS rapidly entered into the forefront of the Astronautics movement in America, helped, undoubtedly, by the rapidly developing space interest in that country which provided a ready source of enthusiastic contributers and a deepening involvement in numerous major space projects.

Particularly interesting for BIS Members will be the many references to our Society which appear in this volume: in fact, it is not far from the truth to say that the AAS was really founded by a group of BIS Members in America, a story which has occured many times before for other countries too - witness the letter published recently from Ing Tabanera refering to the formation of the Argentinian Interplanetary Society.

Not all such Societies stood the test of time, unfortunately, e.g. the South African Interplanetary Society came to a demise after running for a decade or so, but sufficient have carried on to blossom in nationaly-recognised bodies in their own right.

Man in Space
Tim Furniss B. T. Batsford ltd. 72pp 1981 £5.50

The author is emerging as a prolific writer on books about spaceflight for the general public. His present work is a well-illustrated volume, broken down into lively and easily-read chapters which covers manned exploration of space up to and including the Space Shuttle, with the text geared, mainly to a description of individual missions.

NEW-LOOK SOCIETY TIES

In response to a number of requests, the Council has introduced an alternative type of Society tie, dark blue as before, but containing one central motif i.e. our logo just below the knot.

The logo is identical in size to that which appears on the front cover of *Spaceflight.* It shows the central symbolic rocket among the stars surrounded by the name of the Society. The advantage of the new tie is that it is more readily identifiable with the Society than the former version which shows the logo only and which has to be viewed from close-up before detail can be made out (in any event it does not give our name).

The new style tie is available for £6 (£6.50 or $15 abroad) post free.

N.B. Where the new style tie is not specially asked for the "standard tie" will be supplied. The ties were previously advertised at £4.50 but now costs *us* more than that!

From Apes To Astronauts
A. Berry, The Daily Telegraph, 182pp. 1980 £1.45

This is basically a collection of short stimulating articles on a variety of topics from evolution, through astronomy and energy to relativity and the Universe, with side-swipes on the way at a great range of miscellaneous items such as mind-tinkering, super-human machines and time itself.

The section on space travel is relatively short but, usefully, includes the Society's address (unfortunately, 12 Bessborough Gardens) in a nice piece about Daedalus.

Although not wholly space-orientated, many will find this book extremely stimulating reading. It inserts so many pin-pricks in the possibilities which swarm around us.

The Planets
Peter Francis Penguin Books Ltd., 411pp., 1981, £3.95 (softcover)

Man's exploration of the Solar System is proceeding at such a pace that any book on the subject is usually out of date by the time it is published. Voyager's stunning results from Jupiter are included in this volume but not those from Saturn. That said, the book achieves the author's aim: to provide a not-too technical view of the Solar System up to 1980.

As a geologist, the author has clearly been excited by our first close-up glimpses of Mercury (Mariner 10), Mars (Mariner and Viking) and Jupiter's moons (Voyager). Other chapters cover the Moon, Venus, Jupiter, Saturn, meteroids, asteroids, comets and the origin of the Solar System as a whole. Each section looks at the historical picture of planetary astronomy and then switches to our modern knowledge. It really is amazing how our perception of our neighbours has changed in the last 20 years.

Anyone interested in astronomy or space travel will find this a readable and well illustrated book for the price and it will be of particular use to A-level or undergraduate students seeking source material.

Hopefully, there will be a revised version to include findings to come: Voyager, Solar Polar, VOIR, Halley, Galileo, etc.

Bound for the Stars
S. J. Adelman & B. Adelman, Prentice-Hall, 335pp, 1981

This book surveys some of the major problems involved in Solar System and Interstellar Exploration and Utilization. Man's interest in Space, so far, is only beginning. Future benefits, such as inexhaustable fusion power, energy and the end of our water pollution could revolutionise Society.

The book first considers some of the problems, such as living in space for many years at a time and the high cost of space transportation, and suggests how these might be overcome.

Space stations, space colonies and the Lunar Base, even a proposal to transform frigid Mars into a life-sustaining Earth-type planet, are the keys to deep space penetration.

As the title indicates, much of the book is concerned with interstellar exploration, including a very nice reference to Project Daedalus. In fact, the author is a Fellow of the Society and describes himself as such in a Frontispiece.

This is a most readable and very topical book, containing much of absorbing interest.

Cosmos
Carl Sagan, Macdonald Futura, 365pp, 1981, £12.50

The author has already achieved an international reputation for his original and stimulating views. This book is no exception. It is based on his 13 part T.V. series and contains over 250 full-colour illustrations.

The main aim of the volume is to show how science and civilization grew up together so, as one might expect, it ranges from Spacecraft Missions back to the Library of Ancient Alexandria, from the origin of life to the Death of the Sun and, generally, re-trace the steps of cosmic evolution which have led to man, now poised on the brink of Space Exploration, and beginning - increasingly - to wonder about himself.

The book provides fascinating reading and the illustrations are enthralling. It was particularly nice to see a reference to the Society on p. 203, and a reproduction of one of the Daedalus blueprints on p. 204.

Realm of the Universe (2nd Edition)
George O. Abell, Holt Saunders, 438pp. 1980 £10.95 (paperback)

This is yet another example of the magnificent books on astronomy currently available to those with an interest in the subject and who would like to get to grips with a clear, yet informative and detailed appraisal of the topic.

As the author says. "These are terribly exciting times in astronomy", with the universe now being seen in a new light, in more ways than one!

The scope of the volume is extensive, beginning with an overview of the universe, some early history, fundamentals such as gravitation and motion, and then dipping into relativity before the solar system, proper, is even discussed.

Not a great deal of time is spent on the Solar System before we are swinging outwards again towards the distances and the motions of the stars, the properties of stars, and then into the far galaxy. This leads, logically, back to the general theory of relativity, to black holes, and to the structure and evolution of the universe and the posibilities of life.

There are no less than 21 appendices, besides an index and a series of monthly star maps.

Dictionary of Astronomy
R. Maddison, Hamlyn Group, 208pp, 1980, £5.95

This a comprehensive reference work containing over 1500 entries arranged in alphabetical order covering all aspects of astronomy.

Topics dealt with include the bodies in the Solar System, together with comets, meteors and asteroids, as well as stars, galaxies, nebulae, clusters, black holes etc. Also included are references to astronomical instruments, cosmological theories and biographical entries of well-known astronomers, besides articles of the more famous observatories.

References to space research and technology are incidental e.g. the Space Shuttle isn't mentioned and the entry under "Rocket" says "See Surge" i.e. a type of Solar Prominence. There are, however, references to Pioneer and Viking, as well as to UFO's.

Dictionary of Astronomy, Space, and Atmospheric Phenomena
D. F. Tver, Van Nostrand-Reinhold, 281pp. 1979 $14.95

This concise up-to-date compedium describes and defines most of the terms, techniques and equipment relating to celestial phenomena, including the latest concepts in space exploration, planetary research, stellar astronomy and meterology.

The authors explore the general configurations of star groups, galaxy types, new concepts such as quasars, neutron stars (pulsars) etc. The dictionary also includes data provided by the Viking, Mariner and Pioneer space probes & the Voyager flights to Jupiter, besides discussions of meteor showers and astronomical equipment. Charts ais to identify and locate stars, together with reference tables listing e.g. the nearest stars, brightest stars, double and variable stars and clusters.

The Galactic Club: Intelligent Life in Outer Space.
R.N. Bracewell, W.W. Norton & Co., 141pp, 1981, £2.50 (paperback).

It is hard to find a book on outer space nowadays that doesn't, at least, make some passing acknowledgement to Project Daedalus or to the Society's special "Interstellar Studies" issues of JBIS, which now exceed 30 in number and represent a major fund of technical contributions to this study. However, Prof. Bracewell manages it, no doubt because his concern is less with the technology needed to attain interstellar flight and more with the theme of "Are We Alone", followed by how one would contact other intelligent beings by radio means and how, subsequently, to communicate with them.

The bulk of the book is really concerned with the possibility of the existence a Galactic culture, the technology of interstellar travel itself receives a scant 5½ pages of text at the end.

The author's theme is one of considerable interest. His book is well written, stimulating, and makes for easy reading.

CORRESPONDENCE

Dornberger and Bonestell

Sir, After reading the obituary of Dr. Walter R. Dornberger (*Spaceflight,* April 1981), I sent the article to his long-time associate Dr. Ebhherhard Rees in Huntsville, Alabama. He found some of the statements in the article incorrect: Dornberger was born on 6 September 1895, *not* 1885; and he died on 26 June 1980 at the age of 84, *not* 94. Also, the Dornbergers had been residing in Chapala-Jalisco, not Apado, Mexico. Dr. Rees found the obituary interesting and observed that the story of Wernber von Braun igniting the first Kummersdorf liquid rocket engine with a long rod attached to a can of gasoline "was related frequently in Peenemunde."

In reference to the article on the Chelsey Bonestell exhibit at the National Air and Space Museum in Washington (March), the paintings there were loaned by several friends of the artist (inluding me). Readers may be interested to known that I own fifty original Bonestell paintings, most of which were painted in the classic period from the late 40' well into the 1960 decade. The collection, which is on permanent exhibit at the Alabama Space and Rocket Center in Huntsville, is accompanied by an original photo-portrait of Mr. Bonestell by Ansel Adams.

In May I visited Chesley Bonestell in Carmel, California. At 93, he is well, carries on a lively conversation, and paints daily. In fact, he has just completed a set of five renderings of the planet Uranus showing its rather recently discovered ring phenomenon.

FREDERICK I. ORDWAY
Virginia, USA

A Satisfied Speaker

Sir, Thank you very much for your hospitality and kindness when I came to the Society to give a talk last February. I was greatly impressed with your new facilities and the way in which the building has been transformed into an ideal meeting place for members of the Society. I think you and the other members associated with the project have done an excellent job and I am sure that everybody in the BIS will be very proud of your achievements.

Keep up the good work.

DR. GARY E. HUNT
Laboratory for Planetary Atmosphères
University College London

The Daedalus Symposium

Sir, I would like to thank all those concerned with the 'Daedalus in Retrospect' Symposium held at the BIS HQ on May 6. This event proved to be as interesting and stimulating as I could have hoped.

After an optimistic progress report and the interstellar episode from *Spaceships of the Mind*, several speakers moved on to an unexpected field — Daedalus' ubiquitous Wardens.

Can such machines be said to think? Can machines be made to seem to think? How can you tell the difference, if you can't find any difference? Does creativity (our current test) require a random function, a tiny iconoclastic demon forever chipping at the makeshift models, produced and continually patched by our in-built hierarchal, homeostatic pattern makers, that we call reality?

This latter idea seems to parallel both the lateral-thinkers' deliberate 'What if . . .?', and the sudden sense of the incongruous as a familiar, but overstrained connection abruptly parts. It may not be creative thinking, but it may offer a way forwards . . .

By the end of the day, I felt that the Daedalus project may be remembered principally for the Wardens that it spawned!

One thing is certain. Regardless of the evolutionary routes of their design, there will be 'Wardens' about before long; they will play the same role in our future as dogs have done in our past.

It was my first visit to the Society offices — I was very impressed!

N. KELLY
Liverpool

Atlas Launches

Sir, The letter by Stephen Graham in the March 1981 issue of *Spaceflight* provides an interesting example of how your members may often have stored away useful information which is only brought into wider circulation by the pages of your excellent and generally authoritative periodical.

His item (6) suggests the two Atlas Burner missions used either E or F first stages. In fact the 16 August 1968 launch from the WTR (pad SLC-3E) employed an Atlas SLV-3 serial 7004 while the second launch, also from the WTR (pad BMRS A-1), used Atlas 102F. These were the 365th and 403rd Atlas launches, respectively.

I have recently been studying the Atlas launch history and have become interested by the SCORE project. I wonder if any of your readers have any views to offer regarding my suspicion that the Atlas 6-B launch of 18 September 1958 was an unsuccessful attempt to carry out the SCORE mission three months earlier than generally, and officially, acknowledged.

DAVID HOWARD
Chislehurst, Kent

Thor launcher

Sir, In *Spaceflight,* 23, Mar. 1981, a letter by Stephen P. Graham states that the second stage of the LV-2F Thor DMSP launcher is unidentified. According to *Optical Engineering,* 14, July-Aug. 1975, p.275, the second stage is a TE-M-364-4.

JOEL POWELL
Canada

Dornberger Remembered

Sir, Your obituary on the late Walter Dornberger in *Spaceflight* (p.118, April 1981) reminded me of the occasion on which I interviewed him during 8th July 1967.

I'll never forget the bizarre feeling he triggered in me when during the course of the interview after he discussed the successful test of the A-4 he told of the need to go to a high level luncheon meeting in Berlin in an attempt to raise more money. He calmly stated "I had lunch that day with Hitler and he said . . ." I'd never before or since known anyone who had lunch or even breakfast with Hitler.

Incidentally, what the superstitious Hitler had said was "I knew from the agenda what you have come to talk about and I had a dream last night that the rocket would not reach England and, therefore, I will not approve any more money for this project."

For the interested researcher, the complete tape recording of this 90 minutes' interview is part of the 647 reel Michael Kapp Oral History Collection in the library at the National Air Space Museum of the Smithsonian Institute in Washington, D. C.

MICHAEL KAPP, FBIS
California

It was beautiful!

Sir, As a long time Space Buff, I was able to witness the launch of the Shuttle (*via* NASA invitation) from a very close distance. The launch itself was emotional in the extreme. Considering the development difficulties, and the vital importance of a first launching, the absolute success was profoundly satisfying. At 'T' zero, the spacecraft was hidden by the billowing clouds of the water cooling system, and one found oneself praying, yelling and cheering for liftoff. As the launch events occurred with precision, a great sense of relief mixed with pride overcame all present. I followed the Shuttle in clear sky, until SRB jettison, plainly visible through binoculars. Glancing around the gigantic throng, (estimated at 700,000 souls on the Cape alone) I noticed that my eyes were not the only ones with moisture!

H. N. WOLFE

Another BIS Spaceship

Sir, Not every member is aware that more than one BIS spaceship was designed. The pre-War BIS moonship and post-War Daedalus starship have all received well-deserved recognition, but what of the numerous sketches, doodles and "happenings" which found their way on to table napkins, restaurant table cloths, the backs of envelopes, cigarette packets and anything else which happened to be handy?

The BIS records recently yielded up one such, perhaps the only one now extant. Rumour has it that it arrived from Stuart Greenwood (Where are you, Stuart?) one dark night, though whether he arrived *in* it is not recorded.

As one can observe, it contains many novel features, not all of which have found their way into latter-day technology, but might yet do so. Notice the enormous technical advance between this and the earlier Golightly "aerial" craft; it speaks for itself.

A particularly attractive feature is the floating signpost or, as it is known in modern parlance, "Space beacon".

If technical fault can be found, then it will surely be seen when one examines the globe beneath the rocket. This, unfortunately, shows the United Kingdom in the middle of the Atlantic ocean whereas everyone knows that it has now become part of Europe.

A. NON

Do They Keep Away?

Sir, It has been mentioned in the pages of *Spaceflight* that experts are now very pessimistic about the existence of other civilisations in our galaxy. This raised three questions in my mind: if there are superior civilisations, why haven't they contacted us? What can we do to improve our position in the galactic class structure (divided not by ownership or the means of production but by technological and cultural development) and increase our chances of being contacted? And what do we do in the meantime, or if there are no other societies? These questions, I believe, deserve close attention.

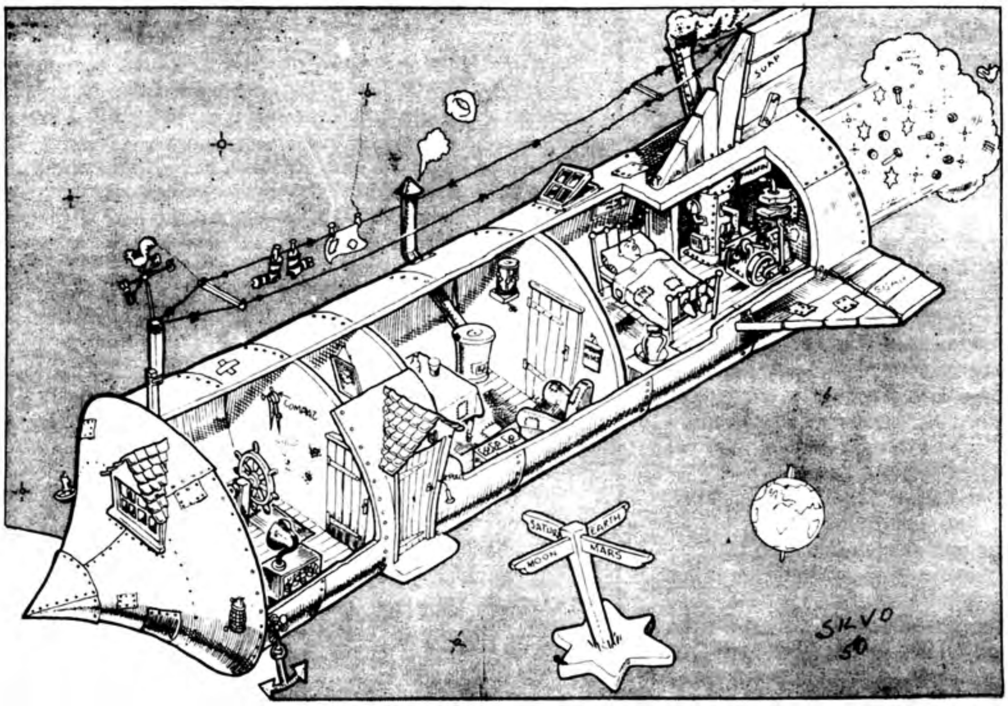
I have seen much discussion about searching for and attempting to contact other civilisations, but have not read anything that talks about why superior civilisations have not contacted us. These societies may have joined forces in a club; they have not contacted us because they feel we are not ready for assistance in climbing the ladder of development. In other words, we do not yet abide by the rules of the club. These rules may become evident only after we've grown a thousand times larger - and smarter.

If other societies are at peace,we may be dangerous and therefore now under close observation. If, on the other hand, new civilisations are common and easily controlled at any early stage, we may be terribly dull to watch. Our observers probably comprehend vastly more information than we produce. Are we progressing at an unusually rapid or slow pace? If rapid, to whom are we promising, or threatening?

Our society must realise that it may be a nature preserve, or in quarantine. If we desire to be contacted, we must become more mature as we grow; as a first step, we should pay close attention to questions such as these.

How can our civilisation improve its position in the galactic class structure? Social stability and moral strength are two likely requirements to join the club, and are desirable for us no matter what. Specifically, we must show that we have, *once and for all,* eliminated genocide and the possibility of Armageddon. Can we do this before we start settling other Solar Systems? If we cannot, we may eventually violate an important rule of the club. Therefore, this question deserves attention in the several centuries before we start leaving our own Solar System.

We may not contact other civilisations for many years (and may never), but we almost certainly will start to colonise the



A tongue-in-cheek design for a spaceship. See the letter head "Another BIS Spaceship".

stars near the Earth within five or six centuries. How can we organise our society so that when we do leave for the stars, the different teams won't lose touch and become as mysterious to those of us left behind as any non-human culture? The prevention of that eventuality, and the obligation of future generations to study Earth history and learn how we moved into space after almost wiping ourselves out, is crucially important; as a first step toward ensuring this, we should become preoccupied with the questions I have raised.

It will take courage and commitment to make this happen, and it's not too early to begin. We are all the founding fathers and mothers of countless worlds to come.

J.L.GARBUS
Maryland, USA

The topics that Mr. Garbus discusses are, of course, very relevant to one of the central areas of Interstellar Studies and have been discussed many times in the literature. More specifically, the red-cover issues of JBIS provide a forum for the treatment of such areas, most recently in "The Fermi Paradox; A Forum for Discussion", JBIS, **32***, 424 (1979), which also included a short bibliography of relevent papers.*

Why? Indeed!

Sir, We are fortunate to have a magazine that has room for articles other than those which deal with the technicalities of spaceflight. It was nice to have an amusing article by Michael Taylor on 'Why' (*Spaceflight*, March '81). The only sad thing is that we might not have any more articles from him in the future. If he follows Wittgenstein's advice (which Wittgenstein being himself didn't) "to say nothing except what can be said" or "whereof one cannot speak thereof one must be silent" then his last article was his "swan song".

I also find it sad when he says that he didn't want to belittle the ideas of A. C. Clarke and Dr. O. Stapledon *et al.* Philosophers are always belittling and deflating each others ideas. It is part of their job. Some go even further, such as Schopenhauer calling the "ontological argument" a charming joke and hence belittling the ultimate.

Logic is a very entertaining art. Zeno, the Greek philosopher, had a few logical jokes of his own, too. He said you cannot step into the same river twice. His students knowing better than their teacher, which is always fun, corrected him by pointing out that you cannot even step into the same river once. The nastiest student said you can't even *step* in the river. The last one is a bit harder to get but is to do with what we mean by "in" and "out".

I think it was Wittgenstein who not only said that it was non-sense to ask "Why the universe" but that it was non-sense to talk of the "universe". The point here is I suppose, as I haven't the reference to hand, that you can only talk of one thing as opposed to another, eg., male as opposed to female, in as opposed to out. Hence if there is no "out" to the universe how can you talk about it? If everything is white how do you know what white is? How can you see the white cat in the snow storm? The statement that the universe is everything is equivalent to "everything is white".

Perhaps Michael Taylor could also have given us a few entertaining quips about the notion of a "thing" as in "everything". Kant had a little bother with it and invented the idea of the "Thing in itself" (*Ding an sich*).

The "Universe" is a bit like Zeno's river. It is not quite the same for any instant of time (if there be such things) assuming always that you don't deny any "ontological status" to things like people, animals, life, art.

A much more fascinating point is this. If there is no external reference point to the Universe, how can we tell if it is expanding or that matter (galaxies, etc.) is contracting. Our observations would remain the same because we have no absolute reference point by which we can demonstrate either. If two spheres shrink then the distance between them increases, and bearing in mind that they can shrink for ever, there being no smallest sphere beyond which there is no smaller, the distance can increase for ever.

As for being a "greyhound" that has refused to run and the hare that is hiding because it doesn't like to be caught that easily, it all depends if you believe that there might be surprises ahead; so that the hare might even be teasing the greyhound!

P. W. KOENIG
Taplow

Not a Mark to be Seen

Sir, I have read the proofs of my article "Tunnelling Our Moon several times and have been unable to find a single word, letter or punctuation mark out of place.

My congratulations to the compositor.

D.J. SHEPPARD
Coventry

Wish it was always so! - Ed.

The Journal

Sir, I must congratulate the Society on its Journal. The range of its subjects in the field of Space is not only highly comprehensive but the manner in which these subjects are grouped, so that each Journal deals separately with the different related aspects of space research, technology, and exploration, is excellent. For example, the February 1981 issue deals with Space Technology and the March issue with Interstellar Studies. Quite apart from the quality of the articles, their grouping is very convenient. It makes reference to the different aspects covered by the Journals much easier for those interested in a specific or wide range of Space activities, and particularly for those involved in Space research.

Many thanks to all those who are responsible for the production of the JBIS.

GROUP CAPTAIN, RAF (Ret'd) DUDLEY SAWARD,
Salisbury, Wiltshire

Heady Wine and Sour Grapes

Sir, Soon after the first Space Shuttle flight, two motions appeared on the House of Commons Order Paper congratulating the USA and NASA on the success of the flight. These so-called "Early Day Motions" though (in theory) set down for future debate, are rarely debated in the House. They are really more a means of expressing opinion, arousing interest or testing the strength of feeling on a subject.

The original proposers of both motions were all Conservatives who, over the following few weeks, attracted a total of 52 signatures including one Labour, one Liberal and one Scottish Nationalist; the rest being Conservative.

Soon after the motions appeared, identical amendments to them were tabled by Frank Dobson; both amendments were supported by Frank Allaun, and one was also supported by Bob Cryer; all three are left-wing Labour Members. Both read as follows: "at end add 'but noting that the achievements of the United States and the Soviet Union demonstrate that given resources and political commitment few technical or material problems cannot be overcome, *calls upon them to end all expenditure on space research and to devote their energies and astronomical resources instead to the elimination of world poverty and hunger*'."

RAY WARD

Voyager Planning

Sir, Dr. Brent W. Silver's AIAA Paper 67-613 appears to be the earliest reference dealing with gravity-assist targeting to avoid passage through the hazardous major rings of Saturn. From that standpoint, Dr. Silver's work was clearly of value in identifying an important consideration in the design of Grand Tour trajectories (see *Spaceflight* correspondence, p.282, October 1981).

I must admit, however, that the selection of Voyager flight paths did not, to the best of my knowledge, incorporate any specific analyses by Dr. Silver into the final designs. The analysts most responsible included such names as P. A. Penzo, J. G. Beerer, F. M. Sturms, A. B. Sergeyevsky, S. A. Collins, E. C. Stone and myself.

C. E. KOHLASE
Voyager Mission Design Manager
Jet Propulsion Laboratory

REFERENCE

1. Correspondence, *Spaceflight*, p. 282, August-September 1981.

The Cost of Fame

Sir, Spaceflight has proved to be too popular! During a recent L-5 Chapter meeting, both the January *Spaceflight* and *L-5 News* were stolen from the display! Maybe it will result in new members?

DONALD F. ROBERTSON
Sacramento, California, USA

Why Man?

Sir, I don't think I have ever read a letter in *Spaceflight* which set me off on such a train of thought and speculation as did Diane Holmes's fascinating contribution published in the June 1981 issue (p. 187).

I wish to comment in particular on her point that in order to develop technology a species needs not only intelligence, but the anatomical equipment necessary to take advantage of the materials the environment has to offer. This is no doubt true, but it is a bit more complicated than that — as I'm sure she realises. The environment itself is also of great significance, and indeed, of course, dictates the physical form of the species living in it. The dolphin's anatomy is, as she says, not much use for performing the sort of controlled movements necessary for a primitive technology, but its smooth, streamlined body, flippers, tail, etc., are perfectly adapted to a water-borne existence.

Also, the sea is a relatively benign environment which does not present the challenges and opportunities, and above all the stimulus, of the harsh, broiled, frozen, storm-wracked, gravity-dominated land.

There is, however, another overwhelming reason, which she does not mention, why the cetaceans, be they ever so intelligent, could never have come near land life in technological achievement, and it too relates to their environment. The point is best made by Arthur C. Clarke who, after speculating on the thoughts of a hypothetical marine genius of millions of years ago, before life emerged from the sea, on what a land-borne existence might be like, says:

"In particular, the very existence, and the infinite uses, of fire would have been utterly beyond his comprehension. The taming and control of fire is the essential breakthrough which leads to the working of metals, to prime movers, to electricity — to everything, in fact, upon which civilisation depends. Though an underwater culture is not inconceivable, it would be forever trapped in the Stone Age." ("Beyond Apollo", epilogue to *First on the Moon: a voyage with Neil Armstrong, Michael Collins, Edwin E. Aldrin Jr.*, written with Gene Farmer and Dora Jane Hamblin, Joseph, 1970, p. 374.)

Clarke also makes the point that today's intelligent marine mammals, the whales and dolphins, are 'drop-outs' from the land, i.e., they have not always lived in the sea, but are descended from creatures which lived on land for a time, then returned to the sea.

RAY WARD
London

MUCH APPRECIATED

Sir, May I say how much I enjoyed the recent Symposium on the Soviet Space Programme (held on 29/30 May 1981 at Society HQ - Ed); equally how much I appreciate the effort put into arranging it by the BIS staff.

CHARLES E. NOAD
London

BINDERS

Sir, I am very pleased to see that the Society has undertaken to issue magazine binders. Now my much-valued issues need not sit in dusty piles on my shelves!

STEPHEN SALMON
London

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

NOTICES OF MEETINGS

1982 SUBSCRIPTION FEES

In spite of a 10% inflation rise the 1982 membership rates are the same as last year, with even a slight reduction for members who remit in US dollars, arising from improved exchange rates.

Amounts payable for the calendar year January-December 1982 are as follows:

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£14.00	$35.00
Between 18 and 20	£16.00	$39.00
21 years of age and over	£18.00	$43.00
Associate Fellows	£20.00	$47.00
Fellows	£20.00	$47.00

Age Allowance

A deduction of £2.00 ($4.00) is allowed to members of every grade who are over the age of 65 years on January 1982.

JBIS Subscription Rate

The additional subscription payable for *JBIS*, where required in addition to *Spaceflight*, is £16.00 ($39.00).

Methods of Payment

(a) Payment should normally be made in sterling with a cheque which shows a UK address, either of the paying Bank or its Agent, where it can be presented for payment.

(b) Payments by US dollar cheques will be accepted if drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover bank and collection charges.

(c) US dollar notes are accepted. Other currencies may also be accepted with prior agreement by the Society. Their value must be sufficient to include conversion costs into sterling.

(d) US or Canadian money orders can only be accepted *if expressed in Sterling*. Internal money orders from these countries i.e. those expressed payable in dollars will be returned as they are not cashable in the UK.

(e) Most Canadian banks have UK branches or agents: remittances may easily be made in sterling drawn on those agents. If payments is made in Canadian dollars the current exchange rate must be used, plus the addition of 12 Canadian dollars to cover exchange and collection charges.

(f) Cheques drawn in sterling on banks in Europe (including Euro-cheques) must include £3.00 to defray bank charges and collection costs.

(g) Banks which remit directly to the Society must be instructed by members to see that the sum transmitted of *free of deductions*. (Banks frequently impose charges "in transit", so the amount actually received by the Society is insufficient to pay for the subscription thus causing much additional correspondence and trouble both to the members concerned and to the Society).

(h) Remittances from Europe can be made by GIRO: this is the easiest and cheapest method of transferring funds. Our GIRO account number is 53 330 4008.

SPACE '82

THE FUTURE OF MANKIND

This will be a new type of Event for the Society, designed with participation by our members in the provinces and abroad (and their wives!) very much in mind. So why not join us at the Picadilly Hotel in London, W.1. on 12th-14th November 1982?

Meet and hear leading personalities in many fields of astronautics and enjoy a range of lectures and other events which will provide an outstanding and most enjoyable weekend.

An outline of the events currently scheduled appears below:

12 November (Friday)

16.00-18.30 Registration

20.00 Buffet Supper with welcoming addresses, L.J. Carter (Executive Secretary): *Meet the Society;*
Introducing some of our Guests of Honour

13 November (Saturday)

9.30-10.15 Guest Speaker: *Journey to Halley's Comet*

10.15-11.00 Guest Speaker: *A Vision of the Future*

11.00-11.20 Coffee

11.20-12.40 Sessions in parallel:
Space Communications: The Universe at our Fingertips
Space: The New Spirit of Adventure

12.40-14.00 Lunch

14.00-16.00 Sessions in parallel:
Into Deep Space
The Energy Problem: Can Solar Power Satellites Provide The Answer?

16.00-16.30 Tea

16.30-18.00 Guest Speaker

20.00 Dinner (dress informal)
Speeches by Guests of Honour
The Society, soon 50 years old - A Look Ahead

14 November (Sunday)

9.30-11.00 Parallel sessions:
Space Education: Key to the Future
Industrialisation: Space in the 21st Century

11.00-11.20 Coffee

11.20-12.00 Guest speaker: *Exploration of our Solar System*

12.00-12.40 Guest speaker
12.40-14.00 Lunch
Closing speeches

There will be plenty of opportunity to see displays and exhibits and to talk about career opportunities.

Registration forms will be available from the Executive Secretary shortly. Applicants should enlose a reply-paid envelope.

Continued on outside back cover

SPACEFLIGHT

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

Continued from inside back cover

Study Course

Theme: **REMOTE SENSING**

A course of eight evening meetings on the above topic, including a visit, will take place during the 1981-82 session. Details are as follows:

30 September 1981	What is Remote Sensing? by Dr. J. R. Hardy
28 October 1981	Platform, Sensors and Data Processing by Dr. J. R. Hardy
11 November 1981	Data Classification and Interpretation by Dr. J. R. Hardy
25 November 1981	Space Oceanography by Dr. J. O. Thomas
9 December 1981	Visit to the Laboratory for Planetary Atmospheres, Department of Physics and Astronomy, University College, London, accompanied by Dr. G. E. Hunt, 6.30-8.00 p.m.
6 January 1982	Remote Sensing: Needs & Applications in Developing Countries by Dr. E. C. Barrett
17 February 1982	Remote Sensing by Landsat and Weather Satellites by Dr. R. Harris
10 March 1982	Evening of technical films on Remote Sensing

The venue will be the Society's Conference Room at 27/29 South Lambeth Road, London, SW8 1SZ. Lectures will run from 7.00 - 9.00 p.m. Course Fee £5.00.

Application forms for registration are available from the Executive Secretary, Please send s.a.e.

Lecture

Title: **RECENT ADVANCES IN SPACE FLIGHT**
by P.S. Clark

A review of space activities throughout the world which have taken place during the past twelve months, to be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ, on **14 October 1981,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Discussion

Theme: **THE SOLAR SAIL RACE**

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ, on **17 November 1981,** 7.00-9.00 p.m.

The Space Technology Committee has organised this meeting to enable those interested to discuss the possibility of flying experimental solar sails in a race, the finishing mark being occultation by the Moon. The sails would be launched by Ariane IV and boosted by a common apogee motor to a few thousand kilometres.

Invited speakers will discuss the opportunity, the mass performance envelopes and general interfaces with the launcher.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **OBSERVATIONS OF THE ATMOSPHERE OF VENUS FROM THE PIONEER ORBITER**
by Dr. F.W. Taylor

To be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ, on **18 November 1981,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show

Theme: **THE MAKING OF AN ASTRONAUT (PART II)**

Further stages in the development of manned space voyages will be illustrated in the following film programme which will be screened at a meeting to be held in the Golovine Conference Room, 27/29 South Lambeth Road, London SW8 1SZ, on **2 December 1981,** 7.00-9.00 p.m.

The programme will include the following:

(a) The Hard Ones

(b) Gemini 11 - Quick Look

(c) Spaceship Skylab - Wings of Discovery

(d) The Mission of Apollo-Soyuz

(e) Space Shuttle - Overview

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

OUR SPACE LIBRARY

The Library will be open to members from 5.30-7.30 p.m. on each of the following dates:

14 Oct. 1981	18 Nov. 1981
2 Dec. 1981	20 Jan. 1982
10 Feb 1982	24 Feb. 1982

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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